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THE MODE OF ORIGIN OF GALLBLADDER LESIONS *

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Much has been written about infection of the gallbladder, but a fairly extensive review of the literature failed to discover descriptions of infectious lesions of the gallbladder in the absence of stones.

The present study of gallbladder lesions was undertaken with the purpose of determining by what processes some of the commonly observed lesions and pathologic states of the gallbladder are produced. At the outset it was thought that a correlation of bacteriologic and histologic examinations of the gallbladder would give this information but discrepancies soon became apparent. Bacteria were often cultivated from gallbladders that showed no lesions and obviously pathologic ones often yielded negative cultures. The micro-organisms cultivated were almost always intestinal or mouth bacteria and in surgical material, manipulation of the gallbladder and duct at the operation made it impossible to exclude contamination from the duodenum. Collateral study of the clinical histories, the operation notes of surgeons and the gross and histologic conditions in the gallbladders gave much more connected and useful information.

Analysis of the clinical histories and operation notes revealed several relevant facts. Recent and extensive changes in the gallbladder were almost always accompanied by severe pain. Acute lesions were frequently not accompanied by febrile reaction or important elevation of the leukocyte count. Recent and extensive changes in the gallbladder were usually associated with the impaction of a stone in the cystic duct. On the other hand, it was found that the impaction of a stone in the common duct was not usually associated with extensive changes in the gallbladder.

Comparison of the gross and microscopic changes in the gallbladder in cases in which cholecystectomy was performed within two or three days after the impaction of a stone in the cystic duct made it clear that the primary lesions in the gallbladder were intramural edema, venous distention and intramural hemorrhage or intramural hematoma.

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* The material on which this study is based was gathered from necropsy material at Hospital Santo Tomas, Panama, Republica de Panama, and from surgical material at the Brooklyn Hospital, Brooklyn.

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The fact that these circulatory changes were not usually attended by important febrile reaction and the absence of thromboses in the cystic vessels made it appear that the circulatory changes were not part of an acute inflammatory reaction but mechanical effects induced by the impaction of a stone in the duct. The veins and lymphatics of the gall-

Fig. 1.—Infarcted and infected gallbladder; recovery was made without peritonitis.

bladder are much more intimately incorporated in the cystic duct than is the cystic artery. The cystic artery is usually isolated and ligated separately. It follows, therefore, that impaction of a large stone in the cystic duct closes off the veins and lymphatics before the artery and causes intramural edema and venous distention. If the stone is

large enough and the interference with the lymph and venous return sufficient intramural hemorrhage or a condition analogous to infarction results.

The material available for study consisted of 403 cases in which cholecystectomy had been performed. The gross and microscopic specimens were carefully sorted, with the aid of the clinical histories, and arranged in the order of the acuteness of the processes observed. Of

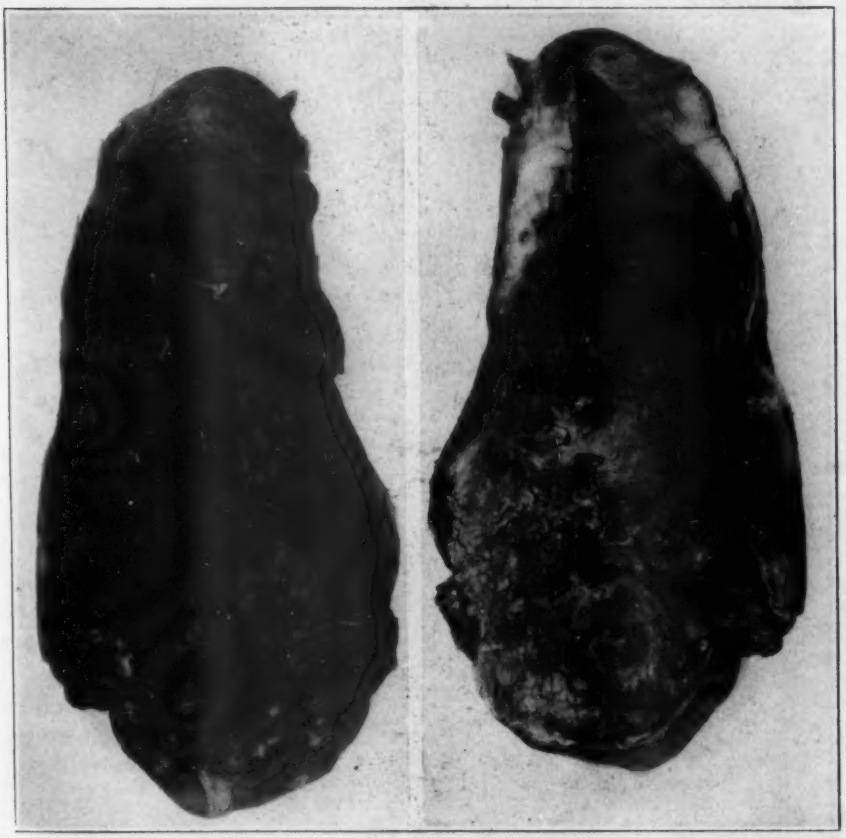

Fig. 2.—Impacted stone and infarcted gallbladder, with colon bacillus in sloughing internal surface. Death occurred four days after operation with peritonitis.

the 403 gallbladders, 188 contained stones. There were definite pathologic changes in 121; the remaining sixty-seven showed only a negligible degree of fibrosis or an atrophic thinning of the wall. In 215 gallbladders that did not contain stones, definite pathologic changes were found in nineteen. In some of the nineteen the clinical histories were very suggestive of the previous presence of stones and the changes were so similar to those in stonebearing gallbladders with pathologic changes

that it is possible that stones had been present but had been passed or were overlooked at operation. In these gallbladders the fact that the circulatory changes were entirely out of proportion to other evidences of inflammation made it appear that some other factor than infection was concerned in the production of the changes.

In reviewing this material ideas gathered from postmortem experience were of material assistance in the evaluation of some of the minor

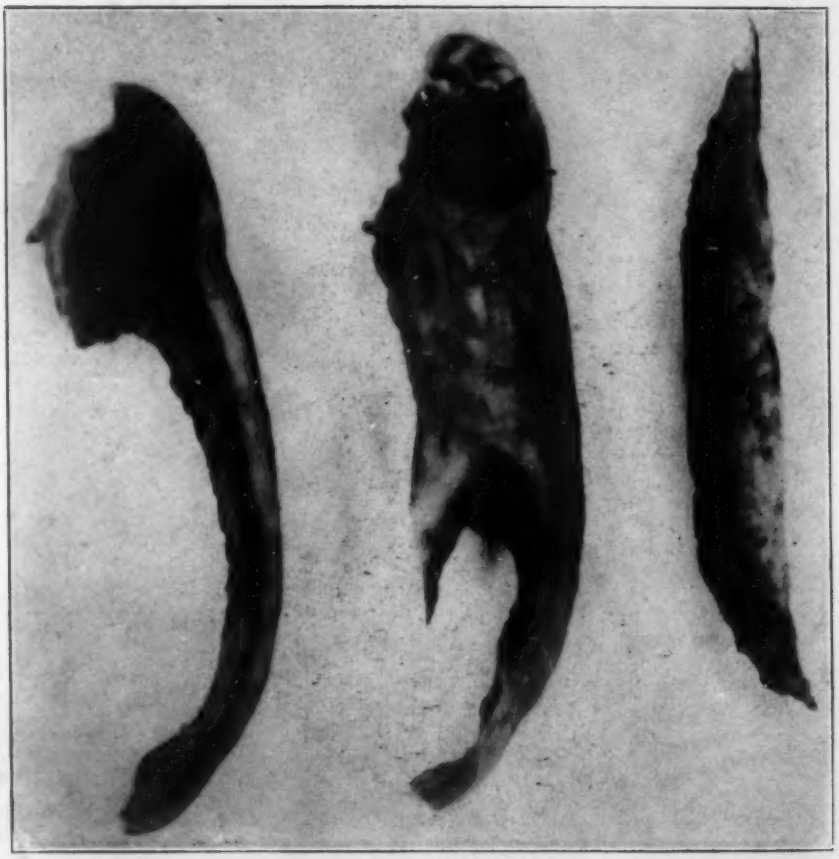

Fig. 3.—Intramural hematoma—the hemorrhage follows two planes, subserous fat and submucous stroma; effect of stone impaction; area not infected.

changes observed in some surgical specimens. Particular attention was paid to the gallbladder and biliary tract in somewhat over 600 necropsies. The structure of the gallbladder can vary considerably in persons of different ages without being in any real sense pathologic. In obese subjects the subserous fat is commonly increased in amount. Slight fibrosis of the fibromuscular tunic, sclerosis of the subserous fat and augmentation of the cells of the submucous stroma have been frequently

observed in postmortem material in which they were clearly of no pathologic significance. Personal experience has taught that it is at times difficult to discriminate grossly between lymph nodes and sympathetic nerve ganglions and occasionally sympathetic nerve ganglions are excised for lymph nodes.

Fig. 4.—Effects of repeated episodes of stone impaction; cicatrized gallbladder with intramural edema and hematoma.

No changes were found in gallbladders that had not contained stones which could be regarded as infectious lesions. No lesions analogous to those commonly met with in acute inflammatory processes in the oviduct, appendix or urinary bladder were found in gallbladders without stones. The only definite change observed where the previous presence of stones

could be excluded was the so-called "strawberry gallbladder." It is difficult to understand just what significance is to be attached to this condition but it gives no evidence of being of an infectious origin.

Recent and mild effects of stone impaction were observed in eight specimens. The gallbladders were slightly distended, tense and salmon colored. Sections showed the effects of interference with the lymph and venous return from the gallbladder as there was coagulated edema fluid

Fig. 5.—Early mechanical effect of edema of subserous fat.

in the intercellular spaces in all coats. The submucous is the most delicate coat and edema and venous distention were the most extensive in this location. The mucous membrane in these specimens was generally intact and unaltered except in small areas where it had been pushed off its backing by edema or by small hemorrhages.

In several specimens analogous but more extensive effects were observed. These gallbladders were distended, tense and bright red or

pinkish red, with splashes of darker red in the subserous fat. The contents were ordinarily pink stained bile. Histologically there was marked edema, venous distention and laceration of the subserous fat compartments and submucous stroma by the edema and hemorrhage. Submucous hemorrhages in particular produced extensive injury to the mucous membrane. In the earliest lesions found there was ample evidence of injury which would excite cellular reaction and cause cellular proliferation in the processes of repair. Organization of hemorrhage was observed to start soon and to proceed rapidly at first. The later processes of removal of necrotic tissue and replacement by scar tissue appear to take a long time. In two specimens in which the interval following the injury could be estimated with considerable accuracy, numbers of mitotic figures could be found in connective tissue cells of the subserous fat within forty-eight hours.

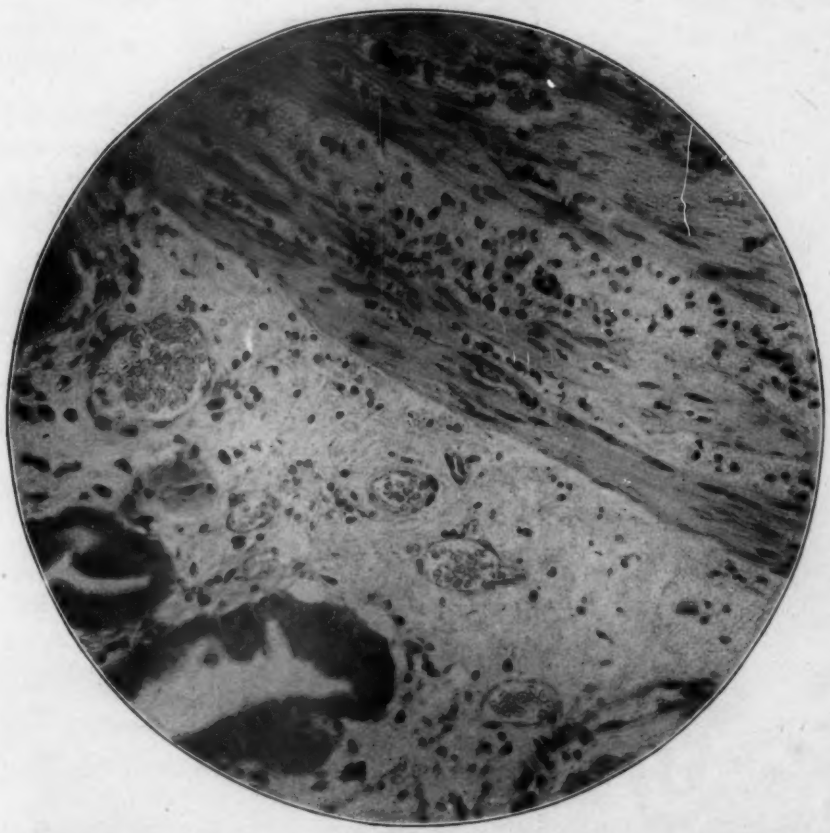

Fig. 6.—Early effects of stone impaction; intramural edema with a few polymorphonuclear leukocytes between stretched muscle bundles.

The most violent lesions observed were in cases in which the impaction of a stone resulted in a condition which has many features in common with hemorrhagic infarction. In these circumstances, the gallbladders were dark red to almost black and friable. In three cases the abdominal cavity contained pink stained fluid. The internal surfaces of the gallbladders presented various appearances, depending on the extent and duration of the process. They were blackish red and smooth or

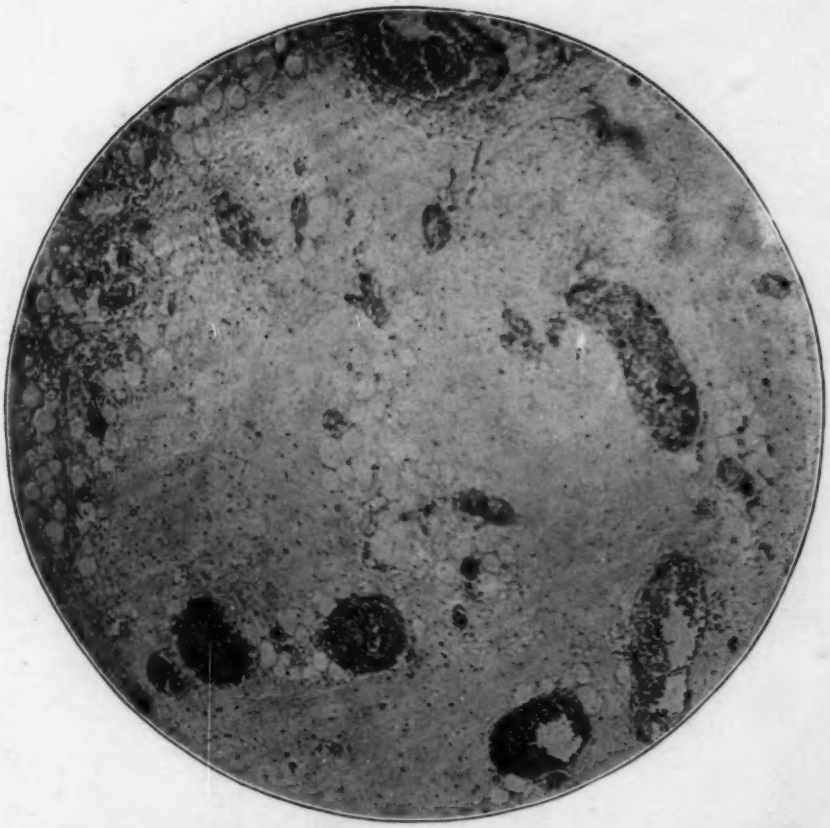

Fig. 7.—Edema and venous congestion in subserous fat associated with stone impaction; the vessels are held apart by coagulated serum.

shaggy with red or grayish red tags and strings of fibrin hanging from the internal surfaces. The contents were bloody fluid mixed with mucous and stones and grayish red or puriform material. Histologically the walls consisted of blood in various stages of disintegration and lacerated connective tissue elements of the wall. The mucous membrane was in most instances almost completely destroyed, but tags of quite normal appearing mucosa could usually be found free in the gallbladder

cavity or attached to edematous stroma. In areas in which the mucous membrane was destroyed there was sometimes a broad zone of blue staining mucous or serous material, beneath this a narrow stratum of leukocytes lying in a matrix of blue staining amorphous material, and beneath this edematous stroma or intramural hematoma. The leukocyte zone was peculiar in that the different varieties of leukocytes were present in about the same proportions as in blood and in some instances

Fig. 8.—Edema of submucous stroma; epithelium detached by shrinkage in technic.

pale shadows of red blood corpuscles were still recognizable between them. The whole appearance was such as one would expect if a submucous hemorrhage had burst into the gallbladder cavity and some digestive ferment had dissolved everything but the leukocytes and a few resistant connective tissue fibers. Microscopic examination of the fluid in the gallbladders supported this view for it was ordinarily found that it contained very few cells of any description and was not pus.

The terminations of these circulatory lesions appear to be diverse. Fatal intra-abdominal hemorrhage has been reported where the gallbladder sloughed. Rupture of the gallbladder can either allow the stones to escape into the abdominal cavity, or a fistula forms with subsequent perforation of the intestine. Stones have been found at necropsy hanging in the omentum like so many grapes without any traces of peritonitis. In three instances in this material a large stone found its

Fig. 9.—Infarcted and infected gallbladder resulting from stone impaction; coagulum in wall escaping into the lumen; colon bacillus and saphrophytic streptococcus.

way into the intestine and caused intestinal obstruction. Secondary infection from the duodenum can result in empyema of the gallbladder or in an intraperitoneal abscess. Neither of the latter conditions are often treated by cholecystectomy as the patients are ordinarily desperately ill by the time infection has occurred and drainage is all that is usually attempted. What is commonly referred to as empyema of the gallbladder would usually be described by some other term if the contents were

examined microscopically. I know of several instances in which stones were overlooked at the time of operation and were found at a secondary operation in a walled off abscess weeks or months later.

The various stages of repair of mechanical lesions and circulatory effects could be followed in cases in which repeated attacks of gallstone colic had preceded cholecystectomy and in cases in which a violent attack of gallstone colic had been allowed to subside before operation.

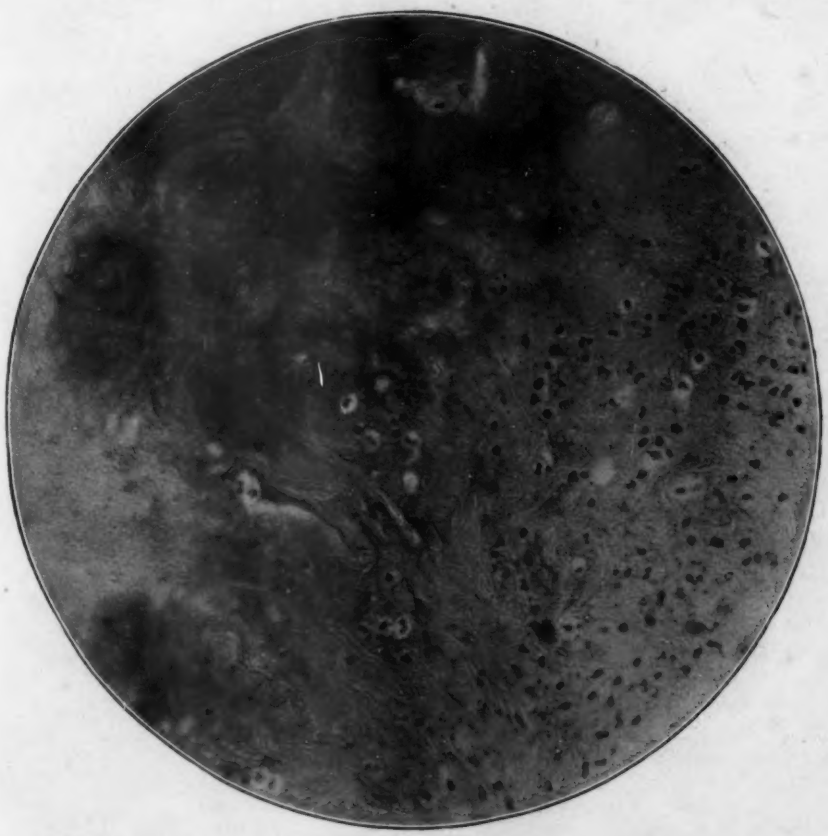

Fig. 10.—Completely infarcted area sloughing into the gallbladder cavity; bacteria are occasionally present in these areas.

Intramural edema and hematoma tend to be replaced by layers of scar tissue of different ages. Extensive thickening can result without any evidence of exudative inflammation and constitute a purely reparative process. The thickening in some instances assumed almost neoplastic proportions from the proliferation of interfascicular connective tissue cells. In several instances the gallbladder was a thick walled bag of scar tissue without a trace of submucous stroma or any residuum of inflammatory reaction.

It was reasoned that if the acute lesions of the gallbladder were primarily infectious, bacterial stains should show what particular micro-organisms were responsible for their production. Thin paraffin sections of ninety-four gallbladders were stained with Giemsa's and Good-pasture's stains after fixation in Zenker's fluid. Twenty-four of the specimens treated in this way were from clinically acute cases and the

Fig. 11.—Repair in gallbladder wall nine days after acute crisis, showing edematous fibroblastic reaction.

lesions were recent. Colon bacilli and coarse gram-positive bacilli were found in the sloughing internal surfaces of four infarcted gallbladders. The lesions in these four cases were primarily intramural circulatory lesions and from the location in which the bacteria were found it is doubtful if they were the cause of the lesions. Bacteria could not be found in the sections of the remaining seventy specimens.

CONCLUSIONS

Recognition of mechanical and circulatory effects is important because they are evidence of cholelithiasis and of entrance of stones in the duct system.

It has not been possible to demonstrate, in this series of cases, lesions that were primarily of bacterial origin.

Other factors than bacterial infection are necessary for the explanation of some of the commonly observed lesions of the gallbladder.

If primarily infectious lesions of the gallbladder occur they must be uncommon.

Lesions of the gallbladder should be regarded as bacterial in origin after demonstration of the causative organism in the lesion a fair number of times.

The terms acute, subacute and chronic cholecystitis are undesirable because they carry the implication of infectious origin and cannot be correlated with clinical conditions. Pathologic states of the gallbladder should be described in morphologic terms as edema, edema and hemorrhage, hematoma, partial infarction, complete infarction, edematous cicatrix and cicatrix.

The presence of gallstones in a gallbladder is not necessarily accompanied by pathologic changes in the gallbladder. In this series of cases approximately two thirds of the stone bearing gallbladders had definite pathologic changes.

THE PATHOGENESIS OF BILIARY CALCULI*

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The conception of disease of the gallbladder is undergoing an interesting change. It now seems that often the early phenomena of disease of the gallbladder are concerned with metabolic changes, rather than bacterial. The study of the formation of gallstones may, therefore, enhance the study of metabolic diseases, as the two appear to be concerned with much the same phenomena.

TYPES OF GALLSTONES

If the classification of gallstones is based on their essential constituents, there are probably only two distinct types, the cholesterin stone and the bilirubin calcium stone. All other types of stones can be grouped with these two. A review of the essential features of each of the gross types of stones may simplify our classification and facilitate the study of the pathogenesis of biliary calculi.

Cholesterin Stone.—Cholesterin stones have been classified in three groups by the pathologist: (1) the pure cholesterin stone, which contains free or conglomerate cholesterin crystals; (2) the radiate cholesterin stone, which is essentially a cholesterin-rich stone, composed of cholesterin crystals arranged in a radiate manner about a nucleus, and containing little other substance, and (3) the "common stone," which has been classified separately but is essentially a cholesterin stone, composed of varying proportions of cholesterin and bile pigment, with fractional amounts of various metals such as sodium, potassium, calcium, magnesium, iron, copper, sulphur, phosphate and zinc.

Bilirubin Calcium Stone.—This stone has been classified separately and probably rightly so. It is usually, but not necessarily, of intrahepatic origin, as multiple stones have occasionally been found in the lumen of the gallbladder alone. The stones are small, black and spicular, and are composed of bile pigment mixed with mucus and traces of calcium, and rarely contain cholesterol. These are the so-called "coral tree stones" that sometimes form casts of the hepatic ducts.

The calcium carbonate stone is usually given a separate classification, but I group it with the bilirubin calcium stone, as it also contains little cholesterol. It is a noninflammatory stone, rare in man, but common in animals.

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* Read before the American Association of Pathologists and Bacteriologists, Washington, D.C., May, 1925.

THEORIES OF STONE FORMATION

Stasis Theory.—Stasis of bile has long been considered a primary factor in the etiology of stones. This condition has been attributed to the inactivity of a sedentary life, with decreased muscular movements of the diaphragm, abdominal wall and enclosed organs. In this connection the rarity of stones in animals and their comparative frequency in man is interesting. Fox [1] has reported only six animals affected in an extensive zoo series, and in 9,000 cattle that I examined in an abattoir only 0.4 per cent had gallstones, whereas 21 per cent of 600 consecutive necropsies at the Mayo Clinic revealed biliary calculi.

The German school emphasizes the effect of constriction of the biliary duct with the resultant stasis of the bile. This is produced by tight clothing and by posture, and they therefore consider corsets, visceroptosis and the asthenic upright habitus of man as frequent predisposing factors in gallstone formation. However, many cases have been found in which undoubted stasis of gallbladder bile has occurred, even in the presence of marked infection, with no indications of gallstone formation.

Infection Theory.—The infective theory of gallstone formation was introduced by Gallipe [2] in 1886, was affirmed by Naunyn [3] in 1892, and today biliary infection is most widely accepted as an essential factor in stone formation. Indeed, Aschoff and Bacmeister [4] regard biliary infection as the cause of all gallstones, with the possible exception of the rare pure cholesterin stone.

Nevertheless, this theory is denied by many, and numerous workers have found gallstones, especially cholesterin-rich stones, when there has been no gross evidence of inflammatory changes in the wall of the gallbladder. The surgeon in particular has seen calculi in gallbladders with thin walls devoid of any of the usual gross stigmas of inflammatory changes. He has frequently had this experience in performing chole-

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1. Fox, Herbert: Diseases in Captive Wild Mammals and Birds; Incidence, Description, Comparison, Philadelphia, J. B. Lippincott Company, 1923.

2. Gallipe, quoted by Rothschild, M. A., and Wilensky, A. O.: Studies in Cholelithiasis: I. The Disturbances of the Cholesterin Metabolism as a Factor in Gallstone Formation, Am. J. M. Sc. **156**:239-247, 1918; II. The Clinical Relationships of the Cholesterinemia to the Pathological Process, ibid. **156**:404-414, 1918; III. The Immediate Effect of the Various Types of Operations upon the Cholesterinemia, ibid. **156**:564-574, 1918; IV. The Late and Permanent Results of the Various Types of Operation on the Biliary Passages with Special Reference to the Cholesterol Metabolism, ibid. **168**:66-77 (July) 1924.

3. Naunyn, B.: Klinik der Cholelithiasis, Leipzig, F. C. W. Vogel, 1892; Klinik der Cholelithiasis, Leipzig, F. C. W. Vogel, 1909; Die Cholelithiasis, Jena, Gustav Fischer, 1921; Die Gallensteine, ihre Entstehung und ihr Bau, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **33**:1-54, 1921.

4. Aschoff, Ludwig; and Bacmeister, Adolf: Die Cholelithiasis, Jena, Gustav Fischer, 1909.

cystectomy for cholelithiasis in cases in which he has been able readily to palpate calculi within the gallbladder in situ. Indeed, the wall is sometimes so thin that it is quite transparent, in many cases not more than 2 mm. thick, which is considered the normal thickness by most anatomists.

The experience of the pathologist has paralleled that of the surgeon. In a series of 612 gallbladders which were removed at necropsy,

Fig. 1.—Cholesterosis of the gallbladder.

although stones were found in many, I found four in which the presence of single or multiple stones was not associated with gross or microscopic evidence of inflammatory changes.

In such cases the type of gallstone is significant, for it is usually in such normal appearing gallbladders that the pure cholesterin or cholesterin-rich stone is found. In the necropsy series studied this fact was striking. The gallbladders containing cholesterin-rich stones were fre-

quently thin walled and comparatively free from inflammatory changes. But with increasing proportions of bile pigment in the stones inflammatory changes in the wall of the gallbladder became more marked. In the cases of dark "common" stones inflammatory changes in the wall of the gallbladder were invariably present, in contrast to the cases of

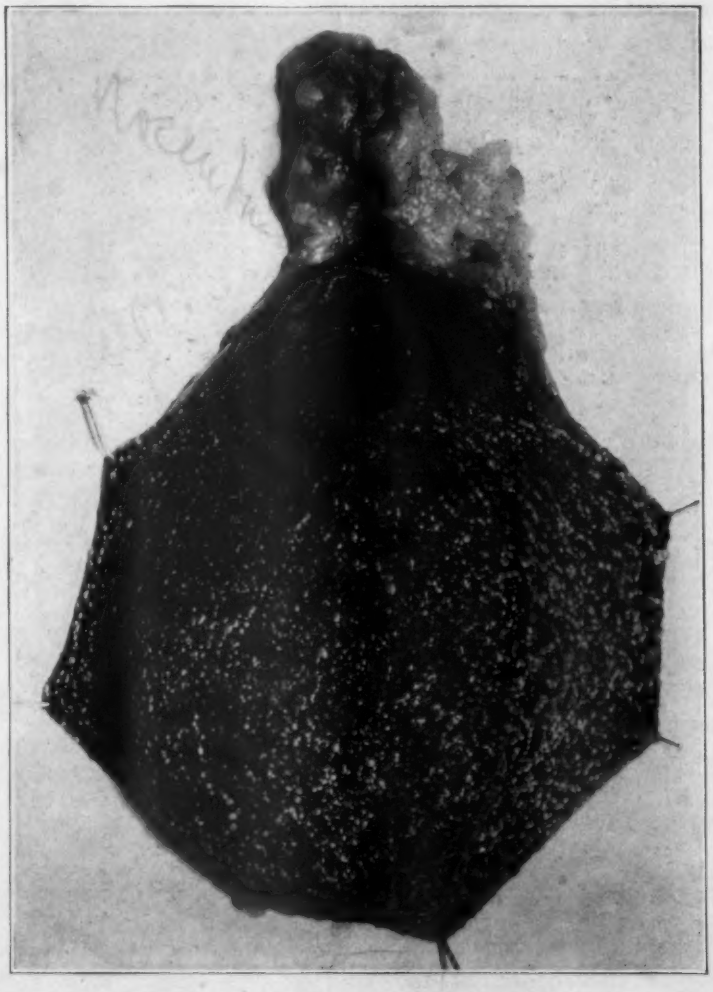

Fig. 2.—Cholesterosis of the gallbladder.

cholesterin stones. This observation suggests that the deposition of bile pigment probably has some relation to inflammatory changes in the wall of the gallbladder, but that cholesterin precipitation occurs independently of such pathologic change.

Gallstones in the new-born have been reported in nine cases. These stones were formed in the fetus, and were therefore presumably not of

inflammatory origin.[5] Also, calculi found in five nurslings have been reported, and these, likewise, were probably noninflammatory in origin. Gallstones have been found in infants and children in increasing numbers as age advances, but the incidence of gallbladder infection likewise increases with age, although it remains remarkably low until adolescence.

Pure cholesterin or cholesterin-rich stones only are found in cases of cholelithiasis without significant inflammatory changes in the gallbladder.

Fig. 3.—Cholesterin polyp of gallbladder containing bile pigment.

The large incidence of gallstones associated with gross evidence of cholesterin disturbance in the wall of the gallbladder ("cholesterosis") is well known to both surgeon and pathologist.[6] In my postmortem study, in 19 per cent of the gallstone cases there were cholesterin stones and in addition gross cholesterin deposits in the wall of

5. Mentzer, S. H.: A Clinical and Pathologic Study of Cholecystitis and Cholelithiasis, Surg. Gynec. Obst. **42**:782 (June) 1926.

6. Mentzer, S. H.: Cholesterosis of the Gallbladder, Am. J. Path. **1**:383-388 (July) 1925.

the gallbladder (figs. 1 and 2). It is significant that the gallstones in cases of cholesterosis of the gallbladder are usually cholesterin-rich stones (cholesterin crystals, radiate cholesterin stones, mulberry stones, gooseberry stones, jack stones or common stones rich in cholesterin).

MacCarty,[7] in his descriptions of the "strawberry" gallbladder, that is, cholesterosis, has noted that the inflammatory changes are often meager. The papillomatous gallbladder, which is but another manifestation of

Fig. 4.—Marked papillomatosa of the gallbladder.

this cholesterin disturbance, is likewise often devoid of any macroscopic or significant microscopic inflammatory change. I am convinced that papillomas play a prominent part in the formation of cholesterin stones, as each papilloma is a polypoid projection of mucous membrane and

7. MacCarty, W. C.: The Pathology of the Gallbladder and Some Associated Lesions, Ann. Surg. **51**:651-669, 1910; The Frequency of Strawberry Gallbladder, Ann. Surg. **69**:131-134 (Feb.) 1919. MacCarty, W. C., and Corkery, J. R.: Early Lesions in the Gallbladder, Am. J. M. Sc. **159**:646-653 (May) 1920.

stroma, laden with cholesterin esters (figs. 3 and 4). Boyd [8] and Stewart [9] believe that these cholesterin-laden polypi break off and lie free in the cavity of the gallbladder, forming potential nuclei for the formation of biliary calculi (fig. 5). I have sectioned numerous "mulberry" gallstones and dissolved out the cholesterin contained within them, noting that the organic structure closely resembled that of the polypi in the papillomatous gallbladder. Naunyn and Aoyama [10] have also noted the organic framework of gallstones. It would seem reasonable that portions of the mucous membrane of the gallbladder laden with cholesterol esters play a significant part in the formation of cholesterin stones by furnishing ideal nuclei for precipitation of bile constituents. However this may be, the pathologist has often seen a "strawberry" gallbladder so thin walled and devoid of gross inflammatory change

Fig. 5.—Cholesterin laden polyp of the gallbladder showing slender pedicle.

that the yellow rugae of the mucosa could be seen through the serosal surface of the organ. The presence of gallstones in such cases is not unusual, and the comparative absence of microscopic inflammatory changes in the wall of the gallbladder is of the utmost importance.

That bacteria are found in the wall of the gallbladder in most cases of gallstones, however, is an undisputed fact. Moreover, gallstones have been produced experimentally in animals by massive intra-

8. Boyd, William: Gallbladder Problems, Canadian M. A. J. **12**:689-693 (Oct.) 1922; Studies in Gallbladder Pathology, Brit. J. Surg. **10**:337-356 (Jan.) 1923.

9. Stewart, M. J.: Xanthoma and Xanthosis, Brit. M. J. **2**:893-896 (Nov. 15) 1924.

10. Aoyama, T.: Zur Frage der Cholelithiasis, Beitr. z. path. Anat. u. z. allg. Path. **57**:169-182, 1914.

venous injections of organisms. Fütterer,[11] Cotton,[12] Wechselbaum,[13] Kraus,[14] Meyer, Neilson and Feusier,[15] and Rosenow[16] have demonstrated the localization of bacteria, so injected, in the wall of the gallbladder. In such instances, however, bacterial emboli occur, producing obstruction of the arterial flow in the villi of the mucosa of the gallbladder and, thus, necrosis of the terminal villi, with resultant sloughing of the tissue. That this is not the usual method of gallstone formation is evident from microscopic studies of the wall of the gallbladder. It seems much more likely that the inflammatory changes in the mucosa and stroma of the diseased organ prevent the passage of water and cholesterol through it, and so disturb the chemical equilibrium of the gallbladder bile.

Contrary to the usual conception of the origin of bilirubin calcium stones is that of Rous and co-workers,[17] who found floccules of bilirubin and calcium carbonate deposited on the glass tubing, in experimental work on dogs with no evidence of inflammatory change in the bile ducts.

Nucleus Theory.—In my examination of several thousand gallstones, a nucleus of some sort was invariably found, and therefore appears to be an important adjunct in stone formation. A nucleus may be a mechanical necessity for the precipitation of the constituents of a stone, or it may be but an incident in its formation. No gallstone is without a grossly demonstrable nucleus. A foreign substance, introduced into the cavity of the gallbladder, will not, alone, cause a stone to form. Cholesterin crystals occur singly, and even in large quantities in the gallbladder without forming stones, a phenomenon that Rous has duplicated experimentally as just described.

The nuclei of gallstones have often been very interesting. For instance, the literature contains twenty-three instances in which the

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11. Fütterer, quoted by Singer, Gustav: Die Gallensteinkrankheit, Berlin, Urban and Schwarzenberg, 1923.

12. Cotton, quoted by Singer, (footnote 11).

13. Wechselbaum, quoted by Singer (footnote 11).

14. Kraus, Ignaz: Beiträge zur Pathologie und Therapie der Gallensteinkrankheit, Berlin, A. Hirschwald, 1891.

15. Meyer, K. F.; Neilson, N. M., and Feusier, M. L.: Mechanism of Gallbladder Infections in Laboratory Animals, J. Infect. Dis. **28**:456-509; 510-542 (May-June) 1921.

16. Rosenow, E. C.: The Etiology of Cholecystitis and Gallstones, and Their Production by the Intravenous Injection of Bacteria, J. Infect. Dis. **19**:527-556 (Oct.) 1916.

17. Rous, Peyton; and McMaster, P. D.: The Concentrating Activity of the Gallbladder, J. Exper. Med. **34**:47-73 (July) 1921; Physiological Causes for the Varied Character of Stasis Bile, ibid. **34**:75-95 (July) 1921. Rous, Peyton; McMaster, P. D., and Broun, C. O.: Studies in Total Bile; Effects of Operation, Exercise, Hot Weather, Relief of Obstruction, Intercurrent Disease and Other Normal and Pathological Influences, J. Exper. Med. **37**:395-420 (March) 1923.

roundworm *Ascaris* formed the nucleus of a gallstone. DeGorce [18] reports a case of forty cholesterin stones, in each of which an *Ascaris* was found, and Novack [19] reports a huge stone, weighing 200 Gm. containing an *Ascaris* in its center. Lobstein [20] has reported a roundworm (*Ascaris?*) in a gallstone, Bouisson [21] a portion of a distoma hepaticum, and Singer [22] has cultured plasmodia from the center of gallstones.

The usual nuclei, however, are masses of bile pigment, so-called "bile thrombi" of Naunyn. Rovsing [23] believes that most of these masses are bilirubin calcium stones that have wandered into the gallbladder from the intrahepatic ducts. Such nuclei as masses of bacteria, mucus plugs, blood coagulum, epithelial cells or cholesterin crystals have been found, however, and occasionally reports of solid foreign particles, such as portions of sutures or needles and even "grape seeds," have been reported in the literature. Nor is it rare to discover that a gallstone of one type has formed the nucleus of a totally different type of stone.

Hypercholesterolemia Theory.—In 1909 Aschoff and Bacmeister [4] introduced the theory that dysfunction of the cholesterin metabolism in the body is a contributing factor in the formation of gallstones. Their views have since won wide acceptance, and there are ever increasing data that bear out their contentions. Aschoff [24] still insists that stasis of bile, gallbladder infection and hypercholesterolemia are necessary for the production of gallstones. Wilensky,[25] the most ardent proponent of the hypercholesterol theory, likewise insists that infection is associated with an increase of cholesterol in the blood and bile in the pathogenesis of biliary calculi.

On the other hand, Rothschild and Wilensky,[26] and Rovsing [23] believe that a saturation of the gallbladder bile with cholesterol alone will precipitate stones, and Dewey [27] has produced gallstones in animals

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18. DeGorce, quoted by Butt, A. P.: Round Worm (Ascaris Lumbricoides) in the Gallbladder, Surg. Gynec. Obst. **35**:215-216 (Aug.) 1922.

19. Novack, quoted by Singer (footnote 11).

20. Lobstein: Report of a Surgically Treated Case of Hemorrhage of Gallbladder which Endangered Life, Gyógyászat, 1923, p. 286.

21. Bouisson, quoted by Naunyn (footnote 3, first reference).

22. Singer (footnote 11).

23. Rovsing, T.: Gallstones, Cause, Not Result of Infection, Acta chir. Scandinav. **56**:103-155; 207-272, 1923.

24. Aschoff, Ludwig: Lectures on Pathology, New York, Paul B. Hoeber, 1924.

25. Wilensky, A. O.: Hypercholesterolemia, Surg. Gynec. Obst. **38**:163-170 (Feb.) 1924.

26. Rothschild and Wilensky (footnote 2).

27. Dewey, Kaethe: Experimental Hypercholesterolemia, Arch. Int. Med. **17**: 757-785 (June) 1916.

by feeding an excessive amount of fat. However, an excess of cholesterol in the bile cannot be necessary in the formation of all types of gallstone, for the bilirubin calcium stone is virtually without any cholesterol in its make-up.

Cholesterin was first noted in gallstones by Conradi [28] in 1775. Since then it has been observed that most gallstones contain considerable cholesterol, many being reported 95 per cent or more "pure cholesterol" by the Bloor determinations. Hypercholesterolemia in association with gallstones has been observed by Wilensky,[25] Rothschild and others.[29] In 200 determinations of the blood cholesterol in cases of gallbladder disease, compared with gallbladders proved "negative" at operation, I also found a relative increase in the blood lipoids. There is, of course, much variation in the cholesterol content of the blood, and although cholesterol values may be low even in the presence of gallstones, the average cholesterol content for a long period of observation will be high.

Huchard,[30] in 1882, first noted the relation of pregnancy to gallbladder disease, and his observations have been amply verified since. Osler [31] stated that 90 per cent of the women with gallstones had borne children, and others have given almost equally high estimates. In a recent postmortem study,[5] I found that 62 per cent of the women who had never borne children had gross gallbladder disease, whereas 77 per cent of the women who had been pregnant were so afflicted. Numerous workers have noted the hypercholesterolemia of pregnancy and the period immediately following parturition, and the well known association of gallbladder symptoms at these times is of suggestive value. In fact, many patients with gallbladder disease date the onset of their first symptoms to the latter months of pregnancy or the period immediately following. That there is a connection between this metabolic cholesterol disturbance of pregnancy and gallbladder disease is strongly supported.

That the metabolic fat disturbance in obesity is likewise associated with gallbladder disease, and especially stone formation, is suggested by necropsy statistics. In a postmortem study of patients weighing over 220 pounds (99.7 Kg.), 90 per cent had gallbladder disease, whereas only 30 per cent of the adult patients weighing 110 pounds (49.9 Kg.) or less had diseased gallbladders.[6]

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28. Conradi, quoted by Boyd (footnote 8, second reference).

29. Rothschild, M. A., and Rosenthal, N.: The Dietetic Management of Hypercholesterinemia in Cases of Cholelithiasis, Am. J. M. Sc. **152**:394-403 (Sept.) 1916.

30. Huchard, quoted by Schrager, V. L.: Clinical Observations on the Etiology of Gallstones in Women, Surg. Gynec. Obst. **38**:344-347 (March) 1924.

31. Osler, William: Modern Medicine, Its Theory and Practice, Philadelphia, Lea and Febiger, 1913-1915.

In this connection, it is interesting, too, that the morbidity of gallbladder disease varies quite remarkably with its geographic distribution. Americans apparently have a higher percentage of gallbladder disease than any other nationality, the postmortem records indicating that about 15 per cent of the adult population have biliary calculi. European statistics likewise give relatively high figures, the incidence from the average necropsy series being 10 per cent, whereas only 3 per cent of the Japanese women have stones [32] and 0.1 per cent of the natives of Java.[33] Lick [34] comments on the rarity of the cases of gallstones among the natives of Africa. It seems apparent that the low fat values of the food intake of these peoples is concerned with the low lipoid content of the blood and bile, which is an inhibitory factor in the formation of the cholesterol "common" stone. Especially significant are these figures, when one recalls that gallstones have been produced experimentally in animals simply by excessive fat feeding.

In 1887 Bristowe [35] suggested that the mucosa of the gallbladder could excrete cholesterol, and Adami [36] and Herter [37] have concurred in this opinion. Recently Dewey,[27] Meyer,[15] Starling,[38] Boyd,[8] Grigaut [39] and Sweet [40] have ventured the opinion that the gallbladder mucosa might absorb cholesterol. I have been induced to agree with the latter by experimental work on dogs, in which lipoidal particles were found passing from the lumen of the gallbladder through the gallbladder wall and into the blood stream [6] (fig. 6).

From these data it seems likely that the prompt passage of lipoidal fat (cholesterol) is sometimes disturbed, with the resultant accumulation of cholesterol in the gallbladder wall, producing the pathologic picture of cholesterosis (that is, the "strawberry" and "papillomatous" gallbladders). When this passage of cholesterol through the gallbladder

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32. Mayaki, quoted by Singer (footnote 11).

33. De Langen, C. D., quoted by Henes, Edwin: Gallstones: Their Basal Etiology, Wisconsin M. J. **20**:220-225, 1922.

34. Lick, quoted by McGuire, Stuart: Opinions on Various Questions in Gallbladder Surgery Based on 1,000 Operations, Virginia M. Month. **50**:688-692 (Jan.) 1924.

35. Bristowe, quoted by Naunyn (footnote 3).

36. Adami, J. C.: On Gallstones and More Particularly Upon Their Cholesterin Constituents, West Canada M. J. **3**:1-17, 1909. Adami, J. G., and Nicholls, A. G.: Principles of Pathology, Philadelphia, Lea and Febiger, 1909.

37. Herter, C. A.: The Etiology and Chemical Pathology of Gallstones, Tr. Cong. Am. Phys. & Surg. **6**:158-194, 1903.

38. Starling, E. H.: The Principles of Human Physiology, Philadelphia, Lea and Febiger, 1915.

39. Grigaut, A.: Le cycle de la cholesterinemie, Paris, 1913.

40. Sweet, J. E.: The Gallbladder: Its Past, Present and Future, Internat. Clin. **1**:187-226 (March) 1924.

wall is interfered with, there is a resultant accumulation of cholesterol in the gallbladder bile. This may reach the stage of supersaturation, or it at least disturbs the colloidal balance holding the cholesterol and bile salts in solution, with the consequent precipitation of these substances.

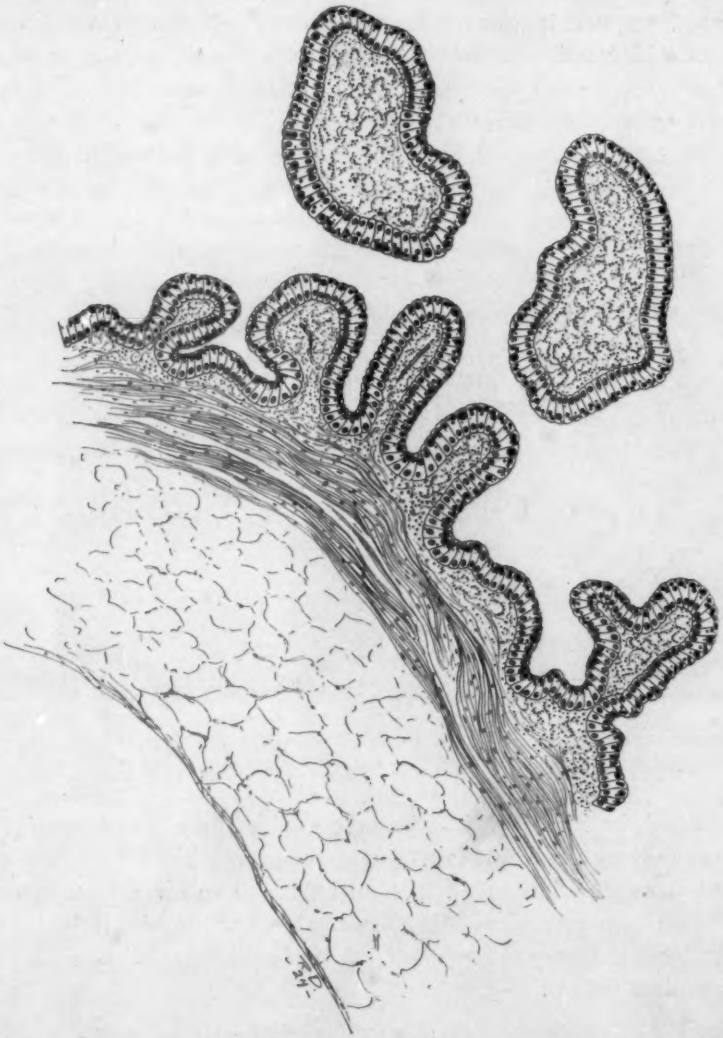

Fig. 6.—Cholesterol accumulation in epithelial cells of the gallbladder wall.

Lichtwitz Theory.—Of great interest is the Lichtwitz [41] theory of gallstone formation published in 1907, according to which bile is a colloid held in suspension by ions of like charges. With a change in the

41. Lichtwitz, L.: Experimentelle Untersuchungen über die Bildung von Niederschlägen in der Galle, Deutsches Arch. f. klin. Med. **92**:100-108, 1907.

acid base reaction of the bile, these charges are altered, resulting in a precipitation of cholesterol. It is probable that the bile salts hold the cholesterol in suspension and that with a change in these salts, and a consequent variation in the acidity of gallbladder bile, this equilibrium is disturbed. The cholesterol content of the bile varies greatly from hour to hour, and it seems quite likely that the bile salt content likewise varies. The conditions, therefore, for such alteration of charges in the cholesterol ions are present; thus, the theory becomes a fascinating one, though difficult to prove.

The experimental work of Oliver [42] is in accord with this theory. Oliver demonstrated that bile in which gallstones had formed would be

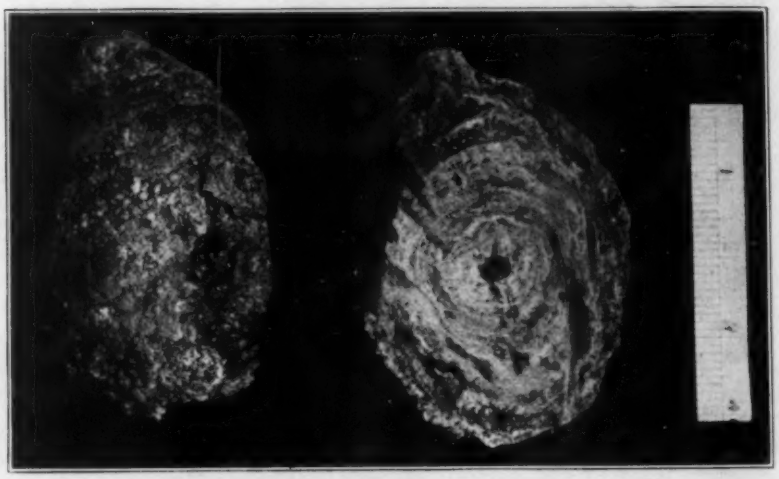

Fig. 7.—Small cholesterin stone, with massive precipitation of cholesterin material about it, completely filling the cavity of the gallbladder.

precipitated in layers if left in a test-tube for a number of hours, whereas normal bile would not. I was able to confirm these observations in some measure, but noted that on exposure to air such bile became alkalinized more rapidly than normal bile. And, indeed, Rous, McMaster and Drury [43] have noted that if acid is added to such bile no precipitation occurs.

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42. Oliver, S. F.: Effect of Bile Salts in the Urine on Routine Tests for Albumin, J. Lab. & Clin. Med. **7**:743-745 (Sept.) 1922; Etiology of Gallstones, J. Lab. & Clin. Med. **8**:242-250 (Jan.) 1923.

43. Rous, Peyton; McMaster, P. D., and Drury, D. R.: Observations on Some Causes of Gallstone Formation: I. Experimental Cholelithiasis in the Absence of Stasis, Infection and Gallbladder Influences, J. Exper. Med. **39**:77-96 (Jan.) 1924; II. On Certain Special Nuclei of Deposition in Experimental Cholelithiasis, ibid. **39**:97-116 (Jan.) 1924; III. The Relation of the Reaction of the Bile to Experimental Cholelithiasis, J. Exper. Med. **39**:403-423 (March) 1924.

The Lichtwitz theory at least explains the sudden precipitation of gallstones, and also the lamination of calculi resulting from intermittent deposits, seen so often in the common stones. I have observed several interesting illustrations of the sudden precipitation of the entire bile content of the gallbladder. In one instance the patient had a laparotomy and during the exploration two large hard gallstones, about 3 cm. in length, were palpated. The gallbladder was otherwise collapsible. A pelvic operation was performed and the abdomen closed. Two days later the patient died from a pulmonary embolus. At necropsy, two large, hard cholesterin-rich gallstones were found, and also a soft, crumbly, brown substance, which was firm enough to be handled, and which when removed, in toto, formed a complete cast of the gallbladder

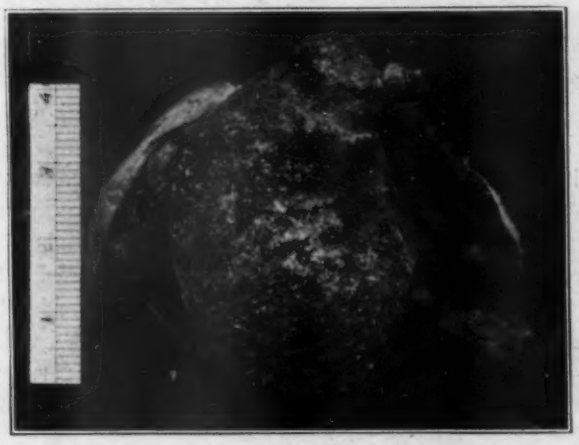

Fig. 8.—Small cholesterin stone, with massive precipitation of cholesterin material about it, completely filling the cavity of the gallbladder.

cavity. The chemist reported it 95 per cent cholesterol. Significantly enough, the gallbladder bile was alkaline.

An equally interesting case was found later, in which a cast of the entire gallbladder cavity was formed, even one of the leaflets of the valves of Heister being visible in the mold. The center of this mass was a radiate cholesterin stone about 1 cm. in length. The chemist reported that this central stone, which was relatively firm and probably very old, was "approximately 95 per cent cholesterol." The cast was a homogeneous mass of bile pigment and cholesterol (figs. 7 and 8).

These two cases illustrate the fact that a sudden massive precipitation of the entire cholesterin content of the gallbladder bile can occur in the gallbladder cavity, and they suggest that the usual laminations of the common gallstone occur in this manner, but that the precipitation is

checked before it is complete, by a recovery in the chemical equilibrium of the bile, which can occur when the excess cholesterin is removed by precipitation and the bile acid base balance is again restored.

SUMMARY

There are probably two types and two sources of gallstone formation: (1) the bilirubin calcium stone containing little or no cholesterol, and arising within the intrahepatic ducts, and (2) the cholesterol stone containing varying degrees of cholesterol and arising within the gallbladder cavity.

Disturbance of cholesterol metabolism of the body generally, or of the gallbladder wall locally, with a resultant increase in the cholesterol content of bile, is probably a primary factor in the formation of gallstones.

Stasis of bile and infection of the gallbladder are not essential to gallstone formation, but both are usually present with all stones.

Nuclei of some sort are invariably present, and are possibly essential to the actual formation of stones. Portions of cholesterol laden mucous membrane lying free in the gallbladder cavity probably form the nuclei for a large portion of cholesterin stones. Without a nucleus it is possible that the ingredients of stones pass out of the gallbladder.

These conditions, namely, an increase in the cholesterol content of the gallbladder bile, the presence of a nucleus and a change in the p_H value of the bile, particularly toward alkalinity, are probably the essential features of cholesterin stone formation in the gallbladder.

UNUSUAL VERTEBRAL INJURIES

REPORT OF CASES *

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The early recognition of a fracture or fracture-dislocation of the spine should not be a difficult task in the light of our present clinical and roentgenologic knowledge. The average physician feels that a person who is not paralyzed and who has not fallen from a considerable height is merely suffering from a strain of the back. The terms "fatality" and "permanent disability" invariably arise as a word picture in the mind of the physician and layman when thinking of fractures of the spine. The failure to request lateral views of the site of injury in addition to anterior posterior roentgenograms is to be condemned. The former are of far greater diagnostic value. Then again, the orthopedic surgeon is consulted late in the course of the condition, during which time the injured has developed an anxiety neurosis in addition to the already existing physical symptoms. This is hard to combat and the treatment and disability are therefore unnecessarily prolonged.

ETIOLOGY

1. Mechanism A. Direct Violence: These cases are rare. B. Indirect Violence: A sudden forced hyperflexion of the spine as a result of falling from a height and landing on the back of the neck and shoulders; a heavy object falling on the flexed trunk, or a sudden muscular contraction in an attempt to lift a heavy object may be the cause of these cases.

2. Location: Fractures of the spine usually involve a single vertebral body. The site of election is the dorsolumbar segment extending from the eleventh dorsal to the third lumbar level. The first lumbar vertebra is the one most frequently affected. Fracture dislocations occur more frequently in the upper cervical and lower lumbar regions, or in the locations that are the most mobile.

SUBJECTIVE PHENOMENA

1. Pain: A. May be referred along the course of the nerves arising from the injured levels. B. Usually is localized to within a small radius of the lesion. C. Is aggravated by attempts at movement of the spine. D. Is referred to the site of the injury when the top of the head is struck or when the patient jumps on his heels.

2. Weakness: A. Of the trunk. B. Of the extremities.

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* Cases presented before the Orthopedic Section of the New York Academy of Medicine, January, 1926.

Fig. 1 (case 1).—Range of flexion and extension one month after the accident.

Fig. 2 (case 1).—Degree of rotation one month after the accident.

OBJECTIVE PHENOMENA

1. Inspection: A, Gait, awkward and careful with the body tilted anteriorly, laterally or both. B. Contour, involvement of the cervical spine may result in a wry neck. The dorsal spine usually presents a small gibbus. The lumbar spine shows a flattening of the region and in addition a small posterior projection may be observed. These findings may be accompanied by a lateral deviation of the spine at the site of injury, and in some few instances an accompanying rotation.

2. Mobility of the trunk: With involvement of the normally mobile spine there is always a total or partial loss of motion either of the entire segment or of

Fig. 3 (case 1).—Appearance two weeks after injury.

the vertebrae adjacent to the site of fracture. The middorsal spine when fractured gives little if any evidence of loss of motion because of its normal rigidity.

3. Palpation: Tenderness is an invariable accompaniment of fracture of the spine and is usually localized to within a short radius of the site of injury. Muscle spasm occurs with all attempts at movement and lends itself to palpation.

4. Neurologic Findings: Sensory changes may be observed in the regions supplied by the injured nerves, and aids in the localization of the exact level of traumatization. Reflexes are found to be hyperactive when the cord is edematous, and absent as a result of sectioning of the cord or from pressure necrosis due to prolonged cord edema. Paralysis of the muscles of the extremities or of the viscera may ensue as a result of cord edema, and is always noted when the cord is sectioned.

5. Ronetgen-ray Observations: Whenever possible at least two views of the spine should be shown. A proper interpretation of the roentgenograms should include: A. Contour: angulation, lateral deviation and rotation. B. Shape of the vertebral bodies: compression, wedging and fragmentation. C. Intervertebral spaces: narrowed; irregular. D. Articular facets and their relationships to one another. E. Fracture of laminae. F. Fractures of transverse processes. G. Fracture of spinous processes and their relationship to one another (may be overlapped in dislocations). H. Productive changes denoting evidences of healing.

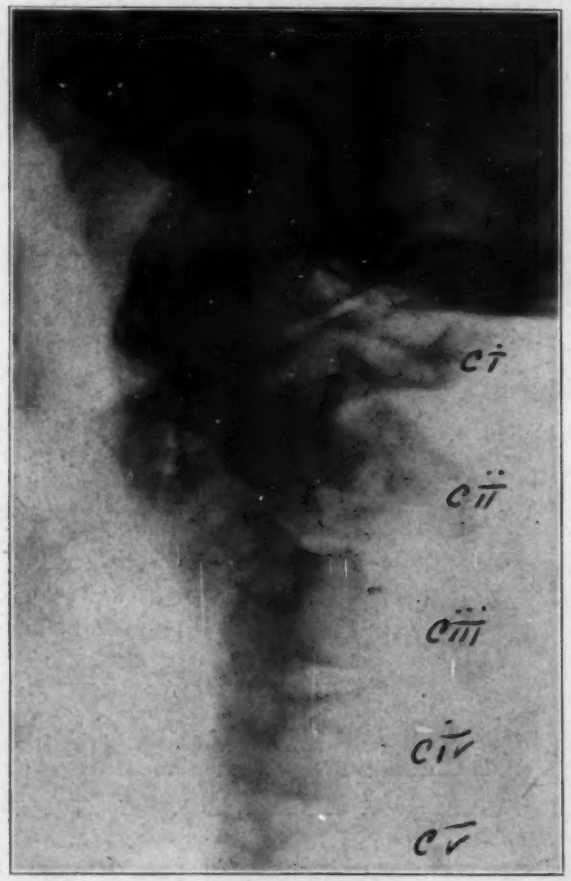

Fig. 4 (case 1).—Appearance one month after injury.

The following case reports are presented because of various unusual phenomena.

REPORT OF CASE

CASE 1.—P. D., a motorman, aged 46, was perfectly well until Nov. 1, 1923, when he lost his footing at the head of a flight of stairs and fell forward, landing at the bottom of twelve steps with his head acutely flexed against the wall. He remained unconscious for twenty minutes. He was removed to his bed, where he remained for two weeks, suffering intense pain for the first twenty-four hours.

Shortly thereafter the pain subsided, and was present only at attempts at movement of the neck. At the end of two weeks he was well enough to get about without support.

He reported to work on the fifteenth day following the accident. The company physician refused to permit him to return to his former occupation of elevated motorman, and suggested that a roentgenogram be made to determine

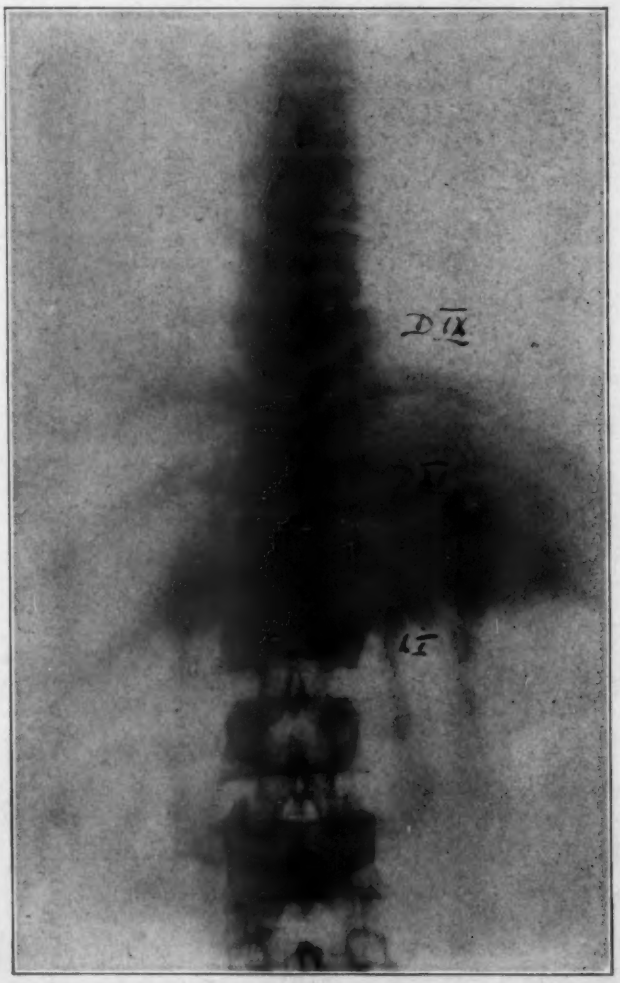

Fig. 5 (case 3).—Anteroposterior view of spine, April, 1924.

the extent of the injury. I saw the patient one month after the accident; the findings were normal except for slight restriction of the rotation of the neck to either side. The patient himself did not complain of pain, weakness or difficulty in swallowing. The roentgenograms brought by the patient showed a dislocation of the second cervical vertebra on the third for a distance of three-sixteenths inch; fracture of the odontoid process at its base with slight angulation, and a chip

fracture of the superior aspect of the lamina of the second cervical vertebra with little separation. The anterior posterior view was of no diagnostic value.

The patient was fitted with a leather collar and received graduated physical therapy. The collar was worn for a period of three months, at the end of which time the patient was discharged as cured and allowed to return to his former occupation. He was last seen in January, 1926, when he stated that he has continued at work and is perfectly well.

Fig. 6 (case 3).—Lateral appearance, April, 1924.

The unusual features in this case are the inability to recognize the lesion without the use of the roentgen ray, the lack of proportion between the roentgen-ray findings and the clinical phenomena; the rapid recovery, and the absence of neurologic signs.

CASE 2.—H. K., a man, aged 59, a sexton and "handy man," was well until Sept. 9, 1920, when while painting the front of a house on a scaffold, he was thrown to the ground by the breaking of a rope. He fell a distance of 14 feet and landed on the back of the neck and shoulders. He did not lose consciousness. He was removed to his home, where he remained in bed for two weeks, being

treated during this time for a sprain of the neck. He was dissatisfied with his physician so placed himself under the care of a chiropractor from whom he received twenty spinal adjustments. Because of failure to obtain relief from pain he sought the advice of another physician, who ordered roentgenograms. The latter, according to the physician, were negative. After about nine months of unsuccessful attempts at alleviation of the pain he came to me.

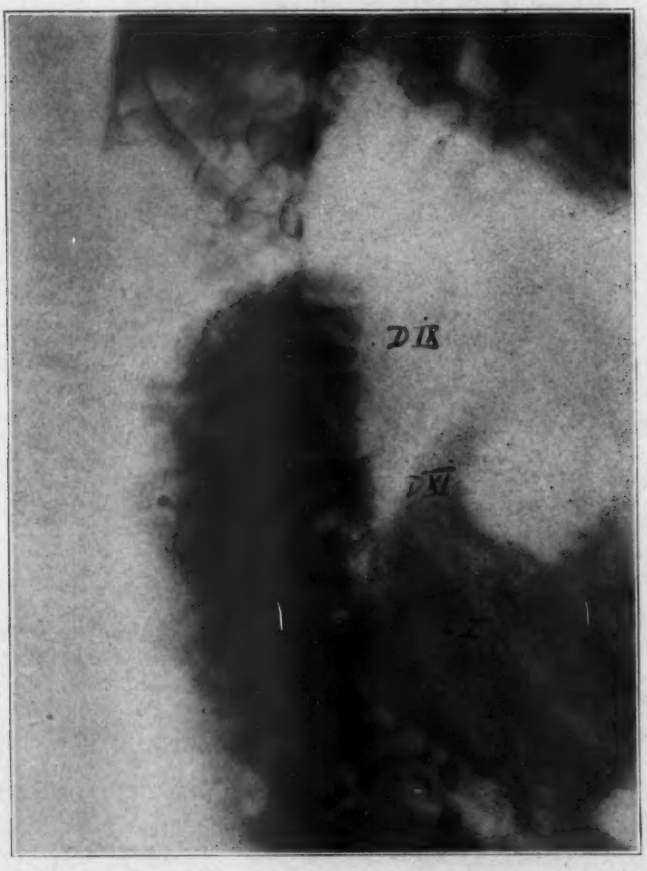

Fig. 7 (case 3).—Lateral appearance, November, 1925.

At this time he complained of persistent pain of the neck, headaches, weakness of the upper extremities and inability to hold the head erect. Examination revealed in addition to the foregoing, a contraction of the anterior muscles of the neck which maintained the cervical spine in an attitude of marked flexion, so much that the chin touched the sternum. Movements of the cervical spine were restricted in all directions, and accompanied by muscle spasm and pain. There was no difficulty in swallowing, no voice changes and no evidence of paralysis. The grip on both sides was weak. No sensory changes were found. The reflexes of the upper extremities were exaggerated; those of the lower extremities were active and equal.

Roentgenograms taken soon after the initial examination revealed in the anterior posterior view an indistinctness of outline of the bodies of the fifth, sixth and seventh cervical vertebrae with an obliteration of the intervertebral spaces between these segments. The vertebrae above and below the site of injury were normal in appearance. The lateral view showed a displacement of the fifth cervical posteriorly for a distance of one-eighth inch. The bodies of both the fifth and the sixth cervical vertebrae were irregular in outline, compressed from above downward and increased in their transverse diameter. The intervertebral spaces were markedly diminished. There were also present proliferative changes of the anterior borders of the fifth and sixth cervical vertebrae.

The diagnosis was fracture dislocation of the cervical spine with involvement of the fifth and sixth cervical vertebrae. The patient was treated conservatively; he was fitted with a leather collar and received physical therapy. He later devel-

Fig. 8 (case 5).—Degree of flexion, November, 1921, and gibbus.

oped radicular symptoms as a result of pressure due to the proliferative bone changes in the region of the intervertebral foraminae. In addition to these he developed an anxiety neurosis. After four years he is still under treatment by the insurance company.

The points of interest are failure of early recognition of the lesion and late nerve manifestations.

CASE 3.—R. F., a chauffeur, aged 20, was first observed April 22, 1924, complaining of pain and stiffness of the back and weakness of the lower extremities. He was well until March 12, 1924, when he attempted to back an automobile on to an elevator on the third floor of a garage; the elevator having been raised to the floor above, the machine dropped through the shaft and landed bottom side up, the patient being found underneath the car. He was removed while unconscious

to a nearby hospital where he remained for three weeks. He was not paralyzed at the time, nor was there any evidence of incontinence. He was discharged from the hospital with a diagnosis of sprain of the back, even though roentgenograms were made.

The patient was well developed; he walked awkwardly, with the body tilted slightly forward and with the right shoulder elevated, and was able to walk only

Fig. 9 (case 5).—Lateral appearance showing fracture of first lumbar vertebra, November, 1921.

a short distance without complaining of pain and weakness. The spine showed the presence of a mild posterior and lateral curvature to the left in the dorsolumbar region. Movements were restricted in all directions, and were accompanied by muscle spasm and pain. Jumping on the heels or striking the top of the head caused the pain to be localized to the first lumbar vertebral region. There was a good deal of muscle tenderness on either side of the spine from the level of

the eighth dorsal to the first lumbar segment. There were no sensory changes. The knee jerks were exaggerated; the ankle reflexes could not be elicited; the abdominal and cremasteric reflexes were active and equal.

Roentgenograms, April 22, 1924, showed the spine deviated to the left in the dorsolumbar region, and compression of the ninth, eleventh and first lumbar vertebrae with an increase in the transverse diameters. There was some irregularity of the inferior surface of the twelfth dorsal vertebra and diminution of the intervertebral spaces between the eighth and ninth dorsal, ninth and tenth dorsal and between the tenth and eleventh dorsal regions. The lateral view showed the presence of a posterior curvature and wedging of the involved vertebral bodies, and in addition fracture of the anterior portions with only slight separation. The intervertebral spaces were only slightly diminished.

Fig. 10 (case 5).—Amount of flexion possible twenty-eight months after accident.

The patient was admitted to the Hospital for the Ruptured and Crippled and placed on a convex stretcher frame without traction. He remained at the hospital for six weeks, receiving daily massage of both the back and the extremities. As a result of this the deformity became almost completely corrected; the knee reflexes became normal. The patient was discharged wearing a plaster jacket. After discharge from the hospital the jacket was renewed from time to time until June, 1925, when a plaster corset was applied, allowing for the institution of physical therapy. The corset was discarded by the patient in November, 1925.

Examination since then showed that the patient is able to flex the spine 75 degrees, extend the back 10 degrees and bend to either side about 25 degrees. He has been working at his former occupation for the last year, and complains neither of pain nor of tiredness. The roentgenogram of November, 1925, shows in the anterior posterior view a slight deviation of the spine to the left in the dorsolumbar region and productive changes of the borders of the twelfth dorsal and

first lumbar vertebrae laterally with fusion. The lateral view reveals complete healing of the fractures of the bodies with the presence of some productive changes of the anterior borders.

The result of conservative therapy has been most gratifying in this instance. This case is unusual because of the involvement of three vertebral bodies separated by normal undisturbed vertebrae.

CASE 4.—G. W., a milk wagon driver, aged 34, was well until August, 1924, when his wagon was struck by an automobile truck and the patient was thrown out. He was removed to a nearby hospital, and was discharged at the end of two weeks

Fig. 11 (case 5).—Amount of side bending possible.

with a diagnosis of sprain of the back and muscular contusions. For the following three months he received baking and massage of the back without relief.

The patient came to me because of the persistence of pain, weakness and inability to work. Examination, November, 1924, showed a well developed man walking about without assistance and presenting a moderate posterior curvature of the dorsal region. There was a small but definite projection at the level of the spinous process of the first lumbar vertebra. Movements of the lumbar spine were partially restricted in all directions, more especially in flexion and extension. These movements were accompanied by muscle spasm. There was tenderness on either side of the spine from the level of the eleventh dorsal to the second lumbar vertebra. The reflexes were active and equal. No sensory changes could be found. Jumping on the heels localized the pain to the first lumbar segment; striking the top of the head did not cause any pain to the injured site.

A roentgenogram of Nov. 29, 1924, disclosed in the anteroposterior view an obliteration of the intervertebral space between the twelfth dorsal and the first lumbar bodies. The lateral view showed the presence of a mild posterior angulation of the dorsolumbar region with the apex at the level of the first lumbar vertebra. The first lumbar vertebral body was wedged, and its anterior superior margin was irregular. There was a diminution of the intervertebral space. The diagnosis was compression of the first lumbar vertebra.

Because of the patient's anxiety to return to his former occupation at an early date the spine was fused from the level of the eleventh dorsal to the fourth lumbar

Fig. 12 (case 5).—Lateral appearance, September, 1923.

vertebra. The patient was able to perform light work three months after the operation, and return to his former occupation one year after my first examination, or fifteen months after the accident.

The features of interest in this case are failure of recognition of the lesion by the hospital staff; absence of neurologic findings, and the ability of the patient to return to his former occupation at a comparatively early date. It is often stated by authorities that a person with a fracture of the spine is unable to return to his former occupation, especially if he is a laboring man.

CASE 5.—G. L., a man, aged 24, a counter man in a restaurant, was well until May, 1921, when while working on board ship he fell 20 feet through a shaft, landing on his back. After two weeks' rest he was able to resume his duties until the ship landed. Since that time he has been unable to work because of persistent pain across the midportion of the back and weakness. He was observed some six months later, when he complained of pain, stiffness and weakness of the spine. The examination revealed findings similar to those described in the preceding case. The roentgenogram disclosed a compression fracture of the first lumbar vertebra. This patient was treated conservatively for two years, at the end of which time there was a complete return of function of the spine and he was able to work sixteen hours a day as a counter man in a restaurant. His duties also included rather laborious tasks. The last set of roentgengrams, taken about

Fig. 13 (case 7).—Depression immediately above the sacrum.

twenty-eight months after the accident, showed that a bridge of bone had formed between the superior anterior border of the first lumbar vertebra and the inferior anterior border of the body above. This bridge of bone became fused to the adjacent vertebral body, thus resulting in a permanent cure.

This case demonstrates the value of conservative treatment in young persons.

CASE 6.—T. W., a carpenter, aged 35, was well until October, 1923, when he fell about 18 feet from a scaffold, landing on the buttocks. He remained at home for a few days and then returned to work, but he had to stop work after one week because of increasing pain in the lumbar region; the pain radiated down the left leg. This patient received baking and massage for several months without improvement, and was referred to me for an opinion as to the cause of the disability. It was said that for years he had had a rotary lateral curvature and that the injury had little to do with the present condition.

Examination, July 29, 1924, showed the patient in good general condition; he walked without a limp, but with a tilting of the body to the left. The right shoulder was maintained higher than the left. The anterior superior spines were on equal levels. There was a loss of the normal lumbar curve, and an accompanying prominence of the left lumbar region. Flexion of the spine was restricted to two-thirds normal; extension was one-fourth normal; bending to either side, one-half

Fig. 14 (case 7).—Anterior-posterior appearance of site of injury.

normal. There was an appreciable deviation of the spine to the left in the upper dorsal region, and to the right in the lumbar location, with the apex of the curve (lumbar) at the level of the third lumbar vertebra. There was a prominence of the spinous process of the third lumbar vertebra and tenderness on either side of the spine in the upper lumbar region. Movements of the spine were accompanied by muscle spasm. The left lower extremity measured one-half inch (1.27 cm.) less

in circumference than its fellow. The limbs were of equal length. Flexion of the extended left lower extremity was restricted and painful. The reflexes were active and equal, and there were no sensory changes.

Roentgen-ray examination showed a deviation to the left in the lumbar spine and an accompanying rotation of the vertebral bodies. The body of the third lumbar vertebra was compressed in its right half and displaced toward the left for approximately one-half inch. There was a separation of the articular facets of the third and fourth lumbar vertebrae. The intervertebral disk between the third and fourth lumbar vertebrae was markedly diminished, and that between the second and third was exaggerated. In the lateral view, the body of the third

Fig. 15 (case 7).—Lateral appearance showing the dislocation of the fourth lumbar vertebra.

lumbar vertebra was displaced forward on the fourth. The intervertebral space was obliterated between the two bodies. The diagnosis was fracture dislocation of the third lumbar vertebra accompanied by a pathologic rotation of the spine.

The unusual feature of this case was the marked amount of rotation of the spine which may accompany a fracture dislocation. That the rotation did not antedate the injury was evidenced by the fact that the remaining segments of the spine showed no distortion (wedging and irregularities).

CASE 7.—P. M., a laborer, aged 45, was first observed in December, 1924, at the Cornell Clinic complaining of pain across the lower part of the back and down the lower extremities posteriorly of several weeks' duration. The patient had worked for the previous twenty years at heavy manual labor and remained well until several weeks before admission, when he slipped down several iron steps while carrying a load of wood on the outstretched forearms.

He was well developed. He walked somewhat awkwardly and carefully, presenting a stiff back with a list of the body anteriorly. The spine from below upward was flattened up to the level of the crests of the ilia; at this site there was a horizontal ledge one-half inch in depth. From here upward the spine was found to be deviated slightly posteriorly. The depression was at the level of the spinous process of the fourth lumbar vertebra. Movements of the spine were moderately free above this region. Extension of the spine was completely restricted. The reflexes were equal, and there were no sensory changes. The extremities were of equal length and presented no evidence of atrophy.

The anterior posterior roentgenogram of the lumbar spine showed a diminution of the vertical distance of the fourth lumbar vertebra. The spinous processes of the fourth and fifth lumbar segments were in close approximation. The intervertebral space between the fourth and fifth bodies was obliterated. The lateral view showed an anterior displacement of the fourth lumbar on the fifth for a distance of one-half inch. There was no evidence of fracture of the vertebral bodies. There was, however, a haziness in the regions of the articular facets between the fourth and the fifth lumbar vertebrae; all other facets could be made out quite clearly.

The patient was admitted to the Hospital for the Ruptured and Crippled in January, 1925, and was operated on. At the time of operation it was noted that the spinous processes of the lower two vertebral bodies overlapped. It was also observed that the last lumbar vertebra could be displaced anteriorly, and when the pressure was released the body would return to its former position. The fourth segment could not be so moved. The region of the articular facets between the fourth and the fifth segments was found to be soft and resembled callus formation. The patient was discharged from the hospital four weeks after operation wearing a plaster jacket. At the present time he is wearing a Knight spinal brace. The movements of the spine are free and painless. There is no muscle spasm. About two months before this article was written he discarded the brace and worked for several weeks at heavy manual labor, but had to stop work because of a recurrence of pain as a result of a sudden twisting strain. He has been advised to return to light work for the present.

The reason for the delayed recovery probably was the failure to insert a bone inlay graft at the time of the operation in addition to the fusion; the patient would not consent to the removal of a tibial graft.

CASE 8.—A. E., a carpenter, aged 54, was well until Nov. 20, 1922, when he slipped down a ladder 14 feet, landing on the base of the spine. He was removed to his home, where he remained for three days. He then returned to work for three days, but suffered severe pain. After that time he was totally disabled, and received various forms of physical therapy for several months without relief.

In September, 1923, the patient complained of pain and disability. The pain was in the lower lumbar region and radiated down the left leg. He walked awkwardly without assistance. In standing he held the left leg in advance and bent the body forward. Motions of the spine were moderately restricted in all

directions, and especially in extension. Striking the top of the head caused no pain in the spine. There was a loss of the normal lumbar curvature, but no evidence of angulation of the spine and no depression immediately above the sacrum. There was tenderness of the left gluteal region and along the course of the left sciatic nerve. The left Kernig sign was positive. The hips were freely movable and painless. The lower extremities were of equal length. The left thigh and calf measured one-half inch less in circumference than the right. The knee reflexes were active and equal, and the ankle reflexes could not be elicited.

The anterior posterior roentgenographic view showed slight deviation of the lumbar spine to the right. There were changes indicative of osteoarthritis of the second and third lumbar vertebrae, and a tilting forward of the fifth lumbar vertebra as evidenced by a visualization of the entire proximal surface. The lateral view showed a displacement of the entire lumbar spine on the sacrum for about three-sixteenths inch. The diagnosis was traumatic spondylolisthesis and ostearthritis.

The patient was admitted to the Hospital for the Ruptured and Crippled and a spine fusion combined with an autogenous bone inlay graft from the tibia was performed in September, 1923. After the operation he wore plaster jackets and finally a Knight spinal brace was applied to facilitate the administration of physical therapy. His condition has been improved locally. About one year after the operation he obtained a position as a bank watchman, and continued at this occupation for one year. Since then he has developed a radiculitis, due probably to the ostearthritis, and is now incapacitated.

The unusual feature in this case is the presence of a spondylolisthesis of traumatic origin.

SOLID TUMORS OF THE URACHUS*

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Articles on urachal cysts are published not infrequently and abdominal surgeons are fully aware of the importance of this condition. On the other hand, the occasional development of solid tumors has not been sufficiently appreciated. The occurrence of a case of the latter kind in my private practice has led me to look up the literature and find out just how many such growths have been reported.

REPORT OF CASE

History.—M. K., a woman, aged 43, was referred to me by Dr. Caleb Athey because of lower abdominal pain and irregular menstrual bleeding. Her family history was unimportant. She had had eleven pregnancies with normal deliveries. There was no history of urinary or gastro-intestinal trouble. Her menstrual periods, until the onset of the present trouble, had occurred regularly, lasting four days and unaccompanied by pain. For six months the menses had occurred twice a month; they had been more profuse than formerly and there had been some bleeding between the periods. Since her first pregnancy, the patient had had a moderate amount of leukorrhea, but this had not increased in amount during the present illness. That she had an umbilical hernia she had known for several years. The symptom, however, that brought the patient to Dr. Athey was pain in the middle of the lower abdomen. This had been present for two years, but in the last few months had increased greatly in severity.

Examination.—The patient was a stout woman who complained of pain in the lower abdomen. The general physical examination revealed no abnormalities. The lower portion of the abdomen appeared somewhat distended. There was an umbilical hernia, the ring of which was 5 cm. in diameter. On palpation of the lower part of the abdomen one could outline a firm mass that extended in the midline from the symphysis pubis to within 2 cm. of the umbilicus. On pelvic examination, the perineum was found markedly relaxed. There was a large cystocele. The cervix was slightly lacerated and unusually firm in consistency. I was not able to differentiate the fundus from the abdominal tumor.

Diagnosis.—The diagnosis was myomata uteri, with a relaxed vaginal outlet. Because of the history of metrorrhagia and the unusually firm consistency of the cervix, it was decided that a dilatation and curettage of the uterus should be performed, a small piece of tissue excised from the cervix and these specimens examined microscopically so as to rule out carcinoma before the hysteromyomectomy was carried out.

Operation.—This was performed at the Church Home and Infirmary, Jan. 2, 1926. After microscopic examination of frozen sections of the uterine curettings and tissue excised from the cervix had shown that no malignancy was present, a lower abdominal midline incision was made. Under the recti muscles, but lying outside the peritoneal cavity was a large tumor which extended from

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the region of the bladder to within a few centimeters of the navel (fig. 1). The recti muscles and their fascias were quite distinct from this tumor and were not even adherent to it. The base of the tumor reached to and rested on the bladder, but was only lightly adherent to it. Through the properitoneal tissue both above and below the tumor were many large veins. The tumor was gray and had a definite capsule. Although situated exactly in the midline of the pro-

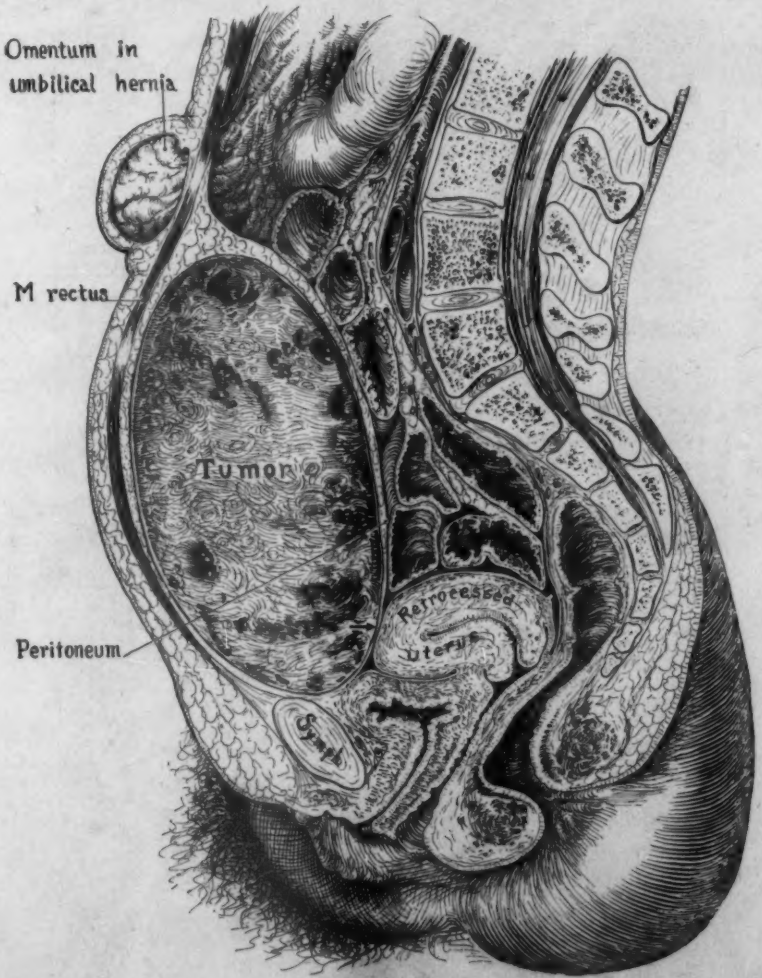

Fig. 1.—Urachal myoma, showing its size and its position in the properitoneal tissue between the recti muscles and the peritoneum (gross section).

peritoneal tissue, it derived its blood supply from vessels entering it from the two sides. The tumor was easily removed without being ruptured or torn. The peritoneal cavity was then entered. A large piece of omentum was found caught in the umbilical hernia. The uterus was normal in size and contained no fibroids; the large properitoneal tumor had pressed it backward into a position of retrocession. The fallopian tubes and the ovaries were normal. The round ligaments contained no myomas or adenomyomas from which the large properitoneal tumor

Fig. 2.—Myoma of the urachus as it appeared after being removed; the dilated lymphatics coursing over its external capsule are prominent.

Fig. 3.—Urachal tumor (cut surface) for the most part presenting the whorl-like appearance of a myomatous growth; scattered through the firm, opaque tissue are islands of semisolid, spongy, translucent material such as one sees when hyaline degeneration has occurred in a myomatous growth.

might have arisen. Inspection from inside the abdominal cavity of the portion of the peritoneum against which the tumor had rested showed nothing unusual. Since the patient was 43, gave a history of excessive uterine bleeding and since the peritoneal cavity had already been entered, a high supravaginal hysterectomy was performed. The umbilical hernia was then corrected in the usual way, and finally the relaxed vaginal outlet was repaired. The patient stood the operation well and one month later left the hospital in good condition.

Pathologic Report.—The uterus was of normal size and, grossly, not abnormal. Microscopic examination of the endometrium showed only moderate hyperplasia. The tumor removed from the properitoneal tissue of the lower abdomen was ovoid in shape (fig. 2), weighed 600 Gm. and measured 14.5 by 9 by 10 cm. The external surface was gray and presented everywhere an unbroken capsule. Numerous dilated blood vessels coursed over its surface and what was especially striking was the great dilatation of the lymphatics. Here and there, attached to its external surface, were bits of connective tissue and fat which were removed with the tumor. Nowhere was there any definite pedicle or stalk leading from the tumor. The cut surface (fig. 3) presented for the most part the whorl-like appearance of a myomatous growth. Scattered through the firm, opaque, grayish white tissue were islands of semisolid, spongy, translucent material such as is associated with hyaline degeneration in a myomatous growth.

The microscopic sections showed smooth muscle tissue with considerable hyaline degeneration in places. The external capsule, which nowhere had been broken through, was made up of fibrous tissue. There was no evidence of malignancy. The diagnosis was fibromyoma of the urachus.

There have been reported, including my own, twenty cases of solid tumors arising from the urachus.

Hue and Jacquin [1] in 1868 described the first of these tumors, but did not themselves recognize the condition, reporting their case as one of colloid cancer of the umbilicus and of the anterior abominal wall. As was pointed out by Frank [2] in 1893, however, one has only to read the original account of these two French writers to feel certain that they were dealing with a primary tumor of the urachus. The following is a summary of their case:

A soldier, when 45 years old, noticed for the first time a firm, smooth tumor about the size of a chestnut which was situated in the midline of the anterior abdominal wall so as somewhat to raise the umbilicus. The regimental physician, thinking that he had to deal with a collection of pus under the umbilicus, made an incision into this tumor but obtained only a small quantity of dark hemorrhagic fluid. After the operation the edges of the incision, instead of healing, continued to spread further and further apart. By the sixth week after the incision into the tumor, there had developed a foul smelling fungating mass, the size of a pigeon's egg, in the region of the navel of which no trace remained. In the center of this fungating mass was a small opening from which purulent fluid poured. It was found possible to introduce a stylet into this opening for a dis-

1. Hue and Jacquin: Cancer colloïde de l'ombilic et de la paroi abdominale antérieure, ayant envahi la vessie, Union méd. **6**:418, 1863. 1868

2. Frank, Thedor: Zur Casuistik der Urachustumoren, inaugural dissertation, Wurzburg, 1893.

tance of 3 cm. The surrounding skin had by this time lost its natural elasticity and taken on a violet color. The general condition of the patient became bad so rapidly that, although a diagnosis of cancer was made, it was felt that further surgical procedures were not indicated. Ten months after the small lump had been noticed under the umbilicus, the entire anterior wall from the navel to the symphysis pubis had become converted into an indurated, compact fungating mass with three fistulas leading into it. Microscopic examination of a piece of tissue removed from the mass showed in the midst of an amorphous substance free nuclei with regular contours and granular contents and also many small round cells. During the last few months the patient complained bitterly of strangury and frequency of urination. Fourteen months after the tumor was first noticed the patient died.

At necropsy the recti muscles were found completely transformed into a gelatinous colloid mass. No trace of muscle fibers remained. The parietal peritoneum under the tumor and the vertex of the bladder had undergone a similar transformation. The posterior surface of the bladder was normal. The prostate showed no abnormalities. In the bladder cavity were two friable gelatinous masses which arose from one base on the anterior superior portion of the bladder at about the point where the urachus was attached to the bladder. These masses appeared to be continuous with the colloid material on the external surface of the vertex of the bladder. Microscopic examinations of gelatinous material in the anterior bladder wall and of the masses in the bladder all showed the same picture as that given by tissue removed from the tumor starting below the umbilicus, but no detailed account of the microscopic picture presented by these tumors is given. It is of interest that Laënnec considered the tumor to be a colloid gelatinous cancer; Virchow thought that it was a hyaline or gelatinous myxoma; J. Müller, that it was a gelatinous sarcoma. Certainly the patient died from a rapidly growing malignant tumor which, from its point of origin in the midline immediately below the navel and its rapid invasion of the umbilical area, with later extension to the bladder, almost certainly had arisen from the urachus and was not a primary carcinoma of the umbilicus. That it is difficult to decide on the exact type of cancer in this case can be understood from the differences in the diagnoses made by such authorities at Virchow, Müller and Laënnec. Possibly, the description of the microscopic observations seems to agree best with that of a sarcoma.

Hoffmann [3] in 1870 reported the second case of urachal tumor. His patient was born with a patent urachus through which urine was discharged at the umbilicus until the age of 3, when following the use of caustics the opening at the umbilicus closed and the patient experienced no further trouble from this condition until he was 27. At that time, however, he noticed an indurated area in the midline of the abdomen between the symphysis and the umbilicus. This area gradually increased in size, extending laterally and vertically so that the umbilicus became prominent. Tenesmus and polyuria next developed and, finally, there was a discharge of purulent material from the umbilicus. The patient died about one year after the tumor was first noticed, the immediate

3. Hoffmann, Carl: Zur pathologisch-anatomischen Veränderung de Harnstrangs, Arch. d. Heilk. **11**:373, 1770. *1870*

cause of death apparently being a peritonitis caused by perforation of the malignant tumor into the peritoneal cavity. Microscopic examination showed it to be a carcinoma of the squamous cell type. In view of the fact that at necropsy a canal was found extending from the umbilicus to the bladder, this case should be considered one of primary carcinoma developing in a patent urachus with secondary involvement of the bladder and umbilicus.

Aveling's case of urachal tumor,[4] which was the next to be reported, is of special interest to me because the tumor he described resembles more closely the one in my case than any other I have been able to find mentioned in the literature.

The specimen in this case was shown, March 10, 1886, before the British Gynecological Society and was at once referred to Dr. Bland Sutton for diagnosis. April 28, 1886, Dr. Sutton[5] presented the following report:

> The tumor is ovoid in shape and measures 10 inches in length and 7 inches in width. It weighs four and three quarter pounds. The growth is surrounded by a distinct and thick fibrous capsule. On section, the tissue is of a dirty white color and the cut surface looks like a sponge. Inside the growth, six or seven hard nodules of the size of walnuts could be felt; these, when dissected out and divided, looked like small leiomyomata such as exist in the uterus, presented the same whorled arrangement of the fibers, and agreed with them histologically. Microscopic examination of the tumor showed that the outer portion consisted of unstriped muscle fibers, some of them being of large size. Internal to this, the cells assumed more the shape and character of those seen in spindle cell sarcomata, while the gelatinous material contained in the loculi is the result of mucoid degeneration of the sarcomatous element.

Although the age of the patient and the clinical history is not given by either Aveling or Sutton in their notes on this case, the microscopic and macroscopic descriptions of this tumor would suggest that the growth was not malignant. The gross and histologic description speaks of nonstriped muscle, and the whole appearance of the tumor suggests a myoma. The areas that were supposed to be sarcomatous may readily have been simply hyalinized fibroid nodules. This interpretation of Aveling's case is also accepted by Cullen, who discussed it in his The Umbilicus and Its Diseases.[6] Figure 4 is a photograph of the original picture of Aveling's tumor as it appeared in the 1886 report of the British Gynecological Society.

Frank[2] in 1893 reported a case of sarcoma which probably had developed in the sheath of the urachus in an 11 year old boy. There

4. Aveling: Brit. Gynæc. J. **2**:56, 1886-1887.

5. Sutton, Bland: Brit. Gynæc. J. **2**:387, 1886-1887.

6. Cullen, T. S.: The Umbilicus and Its Diseases, Philadelphia, W. B. Saunders Company, 1916.

was no history of any difficulty in infancy around the navel or of any urinary symptoms. The condition began with loss of appetite. A few weeks later a tumor appeared in the midline of the abdomen and quickly extended down to the symphysis. At operation, performed six months after the tumor had been first noticed, the recti muscles were found invaded by the growth as was also the outer wall of the vertex of the bladder, and when the peritoneum was opened metastatic sarcomatous nodules were found in the omentum. These findings along with the description of the microscopic sections taken from the tumor left no doubt of the correctness of the diagnosis of sarcoma. The patient recovered slowly from the operation and was well two months later.

Fischer [7] in 1894 reported the following case:

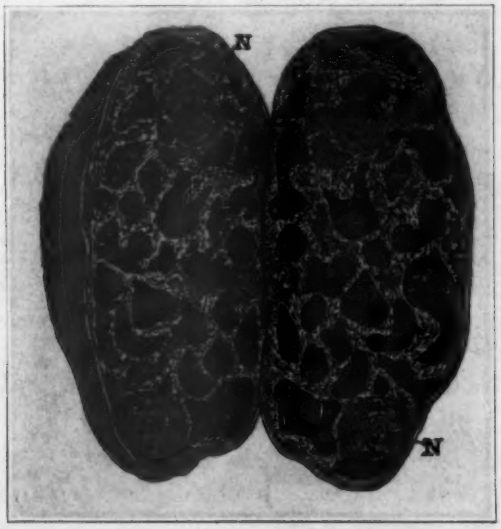

Fig. 4.—Aveling's tumor, an account of which was published in 1886 in the *British Gynecological Journal* (copy of photograph). That it has an external capsule is evident; the cut surface shows definite myomas and the tissue between these tumors resembles that seen in hyaline degeneration.

A man, aged 32, remembered that in his youth, when he passed urine, his navel would become moist. Later, this symptom disappeared. At the age of 32, he for the first time felt a tumor the size of a pigeon's egg under his navel. From then on the growth of this tumor was constant. In a few months burning on urination commenced and a sediment in the urine was noticed. Ten months after he had first noticed the tumor the patient consulted a physician as his urinary symptoms had become severer and the tumor much larger. The family physician, thinking that the tumor was an abscess as it felt rather soft and was in part

7. Fischer: Die Eiterungen im subumbilicalen Raume, Samml. klin. Vortr. n. F., Leipzig, 1894, p. 519.

fluctuant, made a long incision over it and evacuated many clots of rather gangrenous tissue. From the incision tumor masses soon grew which broke down with bleeding. Before long the patient was in a distressing condition. Fischer, who was called in consultation, found the patient very pale and frightfully tortured by severe strangury. Two centimeters below the navel there was a deep crater with its edges heaped up, hard, and projecting over the side of the crater. Its breadth was 8 cm., and the length 7 cm. The floor was very irregular, and covered with hard lumps. The distance from the edges of the skin to the floor of this crater was 5 cm., showing its great depth. The tissue surrounding the crater showed distinct induration and there was a sharp prolongation of this induration down to the region of the bladder. On pressure a thin blood stained fluid containing many bits of tissue was exuded. Although the inguinal glands on both sides were swollen, an operation was decided on. The abdominal wall was opened from the midline to the symphysis. Under the muscle sheath was found a firm tumor which was adherent both in front and behind. The vertex of the bladder was covered with tumor masses, but there had been no perforation of the bladder. The patient died fourteen days after the operation. The microscopic examination of the tumor showed it to be a carcinoma. The intestines and prostate were normal.

In 1897 Rotter [8] reported a case in a man of 43 in which a papillary carcinoma of the bladder had invaded a urachal cyst which had been present from birth. A rather radical resection of the bladder and urachal cyst gave a temporarily satisfactory result, the patient leaving the hospital at the end of two months in good condition and with no evidence of return of the growth. Although this is the only case in the literature of a primary carcinoma of the bladder secondarily invading a urachal cyst, possibly this combination of conditions is not so rare but just happens not to have been more frequently reported. It is interesting that in Rotter's case the findings are just the reverse of those in Hoffmann's in which a primary carcinoma developing in a urachal cyst later invaded the bladder.

In the same year Smith,[9] in his Abdominal Surgery, mentions briefly two additional cases: "Tumors not cystic are found in combination with the urachus-sarcoma, for instance. I have met with two cases of sarcoma. Such cases have, however, a pathological rather than a practical interest." These are all the details given concerning these two cases.

The next report of a urachal tumor is by Villa,[10] an Italian surgeon. A woman of 45 came to him complaining of pain in the abdomen which had been present for three months. On examination he found a solid tumor in the midline of the abdomen which reached from one finger-

8. Rotter: Blasencarcinom kombinirt mit Urachuscyste, Zentralbl. f. Chir. **24**:604. 1897.

9. Smith, Greig: Abdominal Surgery, 1897, vol. 2.

10. Villa, F.: Tumor dell' uraco, Gaz. med. di Milano **1**:65-69, 1902.

breadth below the umbilicus to two fingerbreadths above the symphysis. At operation the recti muscles were found infiltrated with the tumor, the peritoneum under the tumor was implicated and from the lower pole of the neoplasm a firm cord extended down to the vertex of the bladder. Villa performed a very radical operation, removing the primary tumor, the hypogastric portion of both recti muscles and the vertex of the bladder. Although the patient was considerably shocked by the operation, she made a good recovery and eight months later showed no signs of a return of the malignant growth. Although through an accident in the fixation of the tissue, no microscopic sections were obtained, Villa considered that from the macroscopic appearance of the urachal tumor he was surely dealing with a sarcoma.

Koslowski [11] was the next to add to the literature on this subject. His patient, a man of 55, five weeks previously had noticed below his navel a very hard tumor with a band of induration extending from the top of the swelling to the navel. As this patient went so promptly to a surgeon, Koslowski was able to remove the growth with quite a wide margin of healthy surrounding tissue. The patient made a satisfactory recovery from the operation. Because of the irregular glands found on microscopic study to be present in this tumor, Koslowski felt that he was dealing with a neoplasm arising from the remains of the omphalomesenteric duct, but Cullen,[6] Khaum [12] and others who have published their opinions on this case believe the cystlike spaces seen microscopically are simply isolated segments of the urachus that have persisted and that the tumor was really an adenocarcinoma of the urachus.

Goebel's [13] case of carcinoma is of unusual interest. His description appears in an article on *Bilharzia* infections causing cancer of the bladder. In this particular case, Goebel believes that the *Bilharzia* infection attacked a patent urachus, causing a malignant change, and that then, secondarily, the carcinomatous process invaded the bladder. A man of 40 was seen with a fistula 8 cm. wide situated 3 cm. above the symphysis and leading down to the bladder. At the navel was a second fistula that was connected under the skin with the first. The patient stated that one year previously a tumor the size of his fist had appeared over the symphysis, had broken down and ever since had discharged pus and urine. The bladder showed, on cystoscopic examination, a carcinomatous

11. Koslowski, B. S.: Ein Fall von wahrem Nabeladenom, Deutsche Ztschr. f. Chir. **69**:469, 1903.

12. Khaum, Else: Ueber ein primares Karsinom des Urachus, Wien. klin. Wchnschr. **130**:131, 1916.

13. Goebel, Carl: Ueber die bei Bilharziakrankheit vorkommenden Blasentumoren mit besonderer Berücksichtigung des Carcinoms, Ztschr. f. Krebs-forsch. **3**:369, 1905.

involvement of the vertex at the point where the urachus joined the bladder. After the fistula together with the vertex of the bladder had been removed, the fistulous walls were found to have undergone carcinomatous changes, and from careful study of sections taken from the fistula and from the bladder, Goebel decided that the primary carcinoma had arisen in the remains of the urachus and extended to the bladder. He believes that the *Bilharzia* infection had a definite bearing on the bringing about of the malignant change in the urachal remains, since in quite a number of other cases reported in this article *Bilharzia* infections had apparently caused malignant changes in the vesical mucous membrane. The patient did not improve while in the hospital but insisted on leaving twenty-six days after the operation. Since by that time carcinomatous nodules had already appeared in the incision which showed no signs of healing and the patient's general condition was grave, we may conclude that he died soon after leaving the hospital.

In 1909 Doran,[14] in an article on urachal cysts, referred to a case seen by F. E. Eve, the specimen from which had been presented to the Museum of the Royal College of Surgeons, but of which there had never been any publication. Eve's case was that of a man of 38 who for several weeks before being admitted to the hospital had noticed a swelling of the hypogastrium associated with pain on urination. At operation a large cyst was found filled with bloody fluid and intimately connected with the bladder. The cyst was carefully dissected away from the bladder and removed, but the patient succumbed four days after the operation. Eve, after examining the specimen, concluded that it was a large allantoic cyst separated from the posterior surface of the bladder by nothing but a much thinned mucous membrane. The inner wall of this cyst was lined at certain places with very vascular polypoid masses which proved on microscopic examination to be sarcomatous. In spite of the brief clinical history, we may conclude that the case was probably one of sarcoma developing in a patent urachus.

Two German investigators, Schwarz and Michin,[15] in 1912 each reported a new case of urachal tumor. Schwarz's patient was a man of 57 who when first seen had a tumor in the midline between the umbilicus and the bladder. Cystoscopic examination showed that the tumor had secondarily involved the vertex of the bladder. At operation the growth was found to have arisen in the properitoneal tissue beneath

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14. Doran, Alban: Urachal Cyst Simulating Appendicular Abscess; Arrested Development of Genital Tract, Lancet **1**:1304, 1909.

15. Schwarz, E.: Das Carcinom des Urachus, Beitr. z. klin. Chir. **78**:287, 1912. Michin, W. A.: Zur Kasuistik der aus den Resten des Ductus omphalomesentericus sich entwickelnden malignen Neubildungen, Arch. f. path. Anat. **209**: 47, 1912.

the recti muscles, to have invaded the underlying peritoneum and, to have extended, by an indurated stalk of tissue, to the vertex of the bladder. The tumor along with the involved portion of the peritoneum and the vertex of the bladder was removed. The patient made a good recovery from the operation. Schwarz pointed out that this was the first case reported of a primary adenocarcinoma developing in a urachus which had not primarily shown some pathologic condition, such as a cyst, or which had not remained patent for at least a short time after birth.

Michin's patient, a man of 64, entered the hospital complaining of urinary symptoms which had been present for two years. For one year he had noticed in the midline of the abdomen a tumor the size of a hen's egg. Cystoscopic examination showed a hemorrhagic ulcerated process projecting from the vertex of the bladder into the bladder cavity. The urine showed blood, pus and clumps of irregular epithelium which were thought to be carcinomatous in nature. A diagnosis of carcinoma of the bladder was made. At operation a thick-walled cyst was found resting on the vertex of the bladder to which it was quite adherent. The tumor along with the vertex of the bladder was removed. The patient made a good recovery from the operation. Macroscopic and microscopic examination of the neoplasm showed it to be a cyst of the urachus with malignant changes in its walls. Michin, just as Koslowski had done, thought that the presence of true gland elements in his tumor warranted the presumption that it had originated from some embryonic remains of the omphalomesenteric duct, but all those who have since that time discussed his case have considered that both it and Koslowski's started from the epithelium of the urachus.

In 1914 Pendl [16] reported what he thought to be the first instance described of a carcinoma arising from a urachal cyst. He, however, was not entirely correct in this claim, for Michin [17] had antedated him by two years by a report of his case which was of exactly the same type, although the latter had probably incorrectly considered his case to be one of a tumor arising from the omphalomesenteric duct. Pendl, in fact, in his article mentions besides his own only two other cases of solid urachal tumors, namely, those of Hoffmann and Schwartz. His patient, a man of 45, entered the hospital complaining of severe pains in the hypogastrium, polyuria and dysuria. On examination a cystic tumor was found extending from a little below the navel nearly to the symphysis. At operation this tumor was found to have grown tightly to the fascia of the muscle above it, while below it was firmly adherent

16. Pendl, Fritz: Gallertkrebs einer Urachuscyste, Beitr. z. klin. Chir. **91**:681, 1914.

17. Michin (footnote 15, second reference).

to the vertex of the bladder. The tumor was said to have been the size of a man's head, the walls from 2 to 3 cm. thick, with their inner surfaces rough, encrusted and hemorrhagic. The patient made a good recovery from the primary operation, removal of the tumor and the vertex of the bladder. One month later, however, he returned with a metastasis in the abdominal scar. The metastasis was removed, but no further record of the case is given. Histologic examination of the walls of the cyst showed it to be an adenocarcinoma.

In 1916 a German author, Khaum,[12] added another case to those reported of urachal tumors and in the same year Cullen,[6] the first American to write on the subject, published his comprehensive monograph on the umbilicus in which he records a case of adenocarcinoma of the urachus which he had had in his private practice. Khaum, whose article is one of the best on this subject, gives some convincing arguments why the Michin and Koslowski cases should be considered as true instances of urachal tumors. His own case was in a man of 82 who had died with a diagnosis of tumor of the bladder. The diagnosis had been made from the presence of a palpable tumor over the symphysis and hemorrhages from the bladder. At necropsy in the midline of the abdomen a properitoneal tumor which reached from the umbilicus to the vertex of the bladder was found. Only that portion of the vertex to which the urachus was attached was involved by the tumor. Microscopic study showed that the tumor was a colloid adenocarcinoma which, from its position, must have surely arisen from the urachus. Cullen's patient, a woman of 37, for two years before coming under his care had complained of a sharp sticking pain in the left lower abdomen. The abdomen was somewhat distended and percussion showed the presence of fluid. At operation Cullen found a large multilocular cyst adherent to the anterior and lateral abdominal walls. The pedicle of the cyst arose from the top of the bladder. The ovaries were entirely normal. In the pelvis were metastatic deposits, some fully 1 cm. in diameter. The tumor and the appendix were removed. The patient recovered from the operation but died one year later. Microscopic examination showed that the tumor was a multilocular cyst that had become malignant. From its position in the midline of the abdomen, and the fact that it arose from a pedicle attached to the bladder, it is quite certain that it was a urachal tumor.

Five years later we encounter in the literature the next mention of these tumors. Klopp[18] reported the case of a man, aged 50, who for

18. Klopp, E. J.: Patent Urachus with Sarcoma Developing in the Wall, Ann. Surg. **73**:643, 1921.

two weeks had complained of pain around the umbilicus. His history was otherwise entirely normal. There was a small amount of thin yellowish fluid discharging from the umbilicus and it and the skin around it were greatly inflamed. An incision was made above the umbilicus and a small cavity containing a few drops of yellowish fluid was entered. As an intermittent seropurulent discharge continued for two months, a second operation was done. At that time a probe could be introduced into the umbilicus for 5 inches (12.7 cm.). An elliptical incision was made around the umbilicus and continued down to the symphysis and the umbilicus and the surrounding tissue were removed in one piece. The following is quoted from the histologic report:

> The center of the section is occupied by a canal, 0.3 cm. in diameter, a small arc of which is lined with squamous epithelium and probably represents the original tract. The remainder of the wall of the sinus is inflammatory tissue. Near one margin is a mass of mononuclear cells also containing a few giant cells; it is believed that this area is sarcomatous.

The most recent article on this subject is by Nuboer.[19] He reports a case in a man, aged 38, who complained first of pain in the left arm, later on of pain in the abdomen. On examination great tumor masses were found in the hypogastrium, in the inguinal glands, in the left thigh, in the left supraclavicular and infraclavicular groups of glands and, finally, in both axillary groups. At necropsy a cystic tumor was found situated outside the peritoneum, resting on the bladder whose anatomic position made it seem probable that it had risen from the urachus. Tumor masses were found in the small pelvis, in the lumbar vertebrae, in the rectum, in the pancreas in the transverse processes of some of the thoracic vertebrae, in the axillary and inguinal groups of glands and in the skin of the left thigh. Microscopic study showed the abdominal tumor to be cystic in character and filled with papillary growths which were carcinomatous. This is the only case of malignancy of the urachus reported in which such widespread metastases occurred. Most of the metastases, apparently, had developed through the lymphatics, but those under the skin showed that there had also been some spreading of the condition through the blood vessels.

SUMMARY

1. There have been reported, including my own, twenty cases of solid tumors arising from the urachus.

2. The average age of the patients was 44 years. The youngest patient was a boy of 11 with a primary sarcoma of the urachal sheath;

19. Nuboer, J. F.: Ein Fall von Carcinoma Urachi, Arch. f. path. Anat. **254**: 70, 1925.

the oldest was a man of 82 with an adenocarcinoma of the urachus and secondary involvement of the bladder.

3. These tumors have been found more frequently in men than in women. In this series the sex of the patient was not recorded in three cases; in three the patients were women, in fourteen men.

4. In Doran's, Michin's, Pendl's and Cullen's cases the solid tumors developed in the walls of urachal cysts. In Hoffmann's, Fischer's and Goebel's cases malignant growths originated in a urachus that had remained at least partially patent from birth. Goebel's case is especially interesting because a *Bilharzia* infection probably played a part in bringing about the malignant changes in the patent urachus. In the other fourteen cases of urachal tumors we know of no etiologic factors connected with the formation of these growths.

5. These tumors have caused the following symptoms: pain in the middle of the lower abdomen and, when the bladder has been involved, dysuria, polyuria and hematuria. Four patients discovered lumps in the abdominal wall before they experienced any trouble from them. Nuboer's case was unique in that his patient complained of pain in the left arm due to a distant metastasis before the primary growth had given any symptoms or had been noticed by the patient.

6. Eighteen of the reported cases have been malignant, two benign. In nineteen cases the growths arose primarily in the urachus. In one case (Rotter's) a primary papillary adenocarcinoma of the bladder extended to, and secondarily involved, a patent urachus.

7. Of the eighteen malignant tumors, seven were sarcomas, eleven were carcinomas. One of the carcinomas (Hoffmann's case) was squamous in type, the other ten were adenocarcinomas. Pendl and Khaum further describe their cases of adenocarcinoma as being colloid in character.

8. In fourteen of the eighteen cases of malignant urachal tumor, the bladder had already been invaded by the growth when the patient consulted a physician. Whenever this had occurred, there was a broad band of induration extending from the lower pole of the tumor to the vertex of the bladder at the point where the median abdominal ligament (the remains of the urachus) joins that organ. In six instances only the outer coats of the bladder were involved; in eight, cystoscopic examinations showed carcinomatous masses projecting from the vertex into the cavity of the bladder.

9. The tumor in Cullen's case, which must have been a true malignant urachal growth since it was attached by a definite pedicle to the vertex of the bladder, had not invaded the anterior abdominal walls. In all the rest of the cases, at least some invasion of the recti muscles and their fascias had occurred.

10. In only four cases of malignant urachal tumors was the peritoneal cavity found to have been invaded by the growth. Hoffmann's patient, on whom no operation was performed, died suddenly as the result of a perforation of the properitoneal carcinoma into the peritoneal cavity. Frank's patient, a boy of 11, was found at operation to have metastatic sarcomatous nodules in the omentum. The peritoneum beneath the growth, in Schwarz's case, was invaded by the urachal tumor which was an adenocarcinoma, while in Cullen's case, besides a multilocular cyst, which had undergone carcinomatous degeneration, there were metastatic nodules over the pelvic peritoneum.

11. A radical operation was performed in twelve of the malignant cases, in four the condition was too far advanced for surgery to offer any hope of relief. Smith does not record whether or not he operated on his two cases of urachal sarcomas. In seven cases in which a radical exsection of the malignant tumor was carried out, the vertex of the bladder was removed. Cullen's case is the only one in which not even a small part of the recti muscles were removed. Villa removed the whole hypogastric portion of the recti muscles from his patient.

12. Three of the patients with malignant tumors who were operated on died within a few weeks after the operation; Cullen's patient, one year later. The other eight patients are said to have made a good recovery from their operations. Villa and Klopp, however, are the only two surgeons who give any further history of their cases, their patients both being well eighteen months after they had been operated on.

13. It is often difficult to be sure that one is dealing with a malignant tumor of the urachus and not with an inflammatory condition of the anterior abdominal wall due to infection of urachal remains or of urachal cysts. Cullen,[6] in his book on the umbilicus (chapter XXXIII), gives in detail his case of abscess of the anterior abdominal wall arising from urachal remains and summarizes several other such cases reported in the literature. In inflammatory conditions pain is apt to be the first symptom and fever and night sweats soon develop. Malignant growths are frequently accidently discovered by the patient before they produce any symptoms. As secondary infection, however, not infrequently occurs in malignant urachal growths, the absolute diagnosis between these two conditions can often not be made until after microscopic study of the tissue removed at operation.

14. My case was one of benign fibromyoma which had arisen from the sheath of the urachus. There is no history to suggest that the patient's urachus had remained patent in infancy nor was any cyst of the urachus present. In the medical literature, I have been unable to find any other case of benign urachal tumor reported as such. I

agree, however, with Doran and Cullen that Aveling's tumor was really a benign fibromyoma of the urachus instead of a sarcoma, as he supposed it to be.

15. My study of malignant urachal tumors has impressed me with the fact that these growths occur more frequently than had previously been supposed, and that to cure these cases a very radical operation must be performed, usually including removal of the vertex of the bladder and portions of the anterior abdominal walls.

PRIMARY MALIGNANT TUMORS OF THE LONG BONES

END-RESULTS IN ONE HUNDRED AND SEVENTY OPERABLE CASES*

WILLIAM B. COLEY, M.D.
AND
BRADLEY L. COLEY, M.D.
NEW YORK

Continued from page 836

REPORT OF CASES

CASE 1.—*Recurrent spindle cell sarcoma of tibia; amputation advised by other surgeons; treated with toxins alone; patient well, with a normal limb, at present, twenty-six and one-half years later.*

W. F., a man, aged 27, first noticed a swelling of the left tibia at the junction of the middle and upper thirds in March, 1897; this slowly increased in size and, July 28, he was operated on by Dr. Stewart of Toronto, Canada. A prompt recurrence took place and, November 25 of the same year, a second operation was performed, consisting in incision and curetting of the bone; the tissue was sent to Dr. John Caven, professor of pathology, University of Toronto, who pronounced it a spindle cell sarcoma. The tumor again recurred, and the patient was referred to us for toxin treatment in February, 1899.

Physical examination at this time showed a tumor at about the junction of the middle and upper thirds of the left tibia, measuring 3 by 4 inches (7.6 by 10.1 cm.), with an ill defined border; over the central portion were two ulcerations the size of a silver quarter. The patient was admitted to the Memorial Hospital, where the mixed toxins of erysipelas and *Bacillus prodigiosus* (Coley) were begun at once and continued for about two months. The tumor rapidly disappeared and the bone cavity healed with healthy granulations. Before the healing process was entirely completed, the patient contracted a severe attack of accidental erysipelas (a patient with a fresh case of erysipelas had been in the ward not long before), which ran the usual course of about ten days. Healing continued rapidly and was completed two or three weeks later, after which the patient returned to his home in Canada. At the present time, twenty-six and one-half years later, he is in excellent condition with a sound and useful leg, and is able to attend to his duties as a farmer.

CASE 2.—*Round cell sarcoma of humerus; treated with mixed toxins; limb saved; patient well twenty-four years and then died of spinal metastases.*

A. C., a woman, aged 31, was a patient of Dr. J. Bapst Blake of Boston, who performed an exploratory operation in 1899, revealing a tumor which involved

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[ED. NOTE.—This article, because of its great length, has been divided into two parts; the first part, containing a discussion of this subject and tabulations of the cases treated, appeared in the December issue.]

*Read in part before the annual meeting of the Association of British Surgeons, London, May, 1923, and before the American Surgical Association, Washington, D. C., May 5, 1925.

*This series of 170 cases includes periosteal sarcoma, subperiosteal sarcoma, the type of tumor characterized by most pathologists as round cell sarcoma and by Ewing as endothelioma, and a small group of malignant central tumors.

*From the Department of Bone Sarcoma, Memorial Hospital, and the Hospital for Ruptured and Crippled.

Fig. 1.—Myositis ossificans of femur simulating periosteal sarcoma.

Fig. 2.—Syphilitic osteitis of radius closely simulating sarcoma.

not only the head of the humerus, but the tip of the coracoid and part of the glenoid cavity as well. An interscapular thoracic amputation was advised but refused. No attempt was made to remove the entire tumor at operation. The patient was immediately put on the mixed toxins of erysipelas and *Bacillus prodigiosus,* and the treatment was carried out under my direction. She made a complete recovery with full restoration of function, and remained in excellent health until 1921, or twenty-two years later, when she developed what was

Fig. 3.—Periosteal osteogenic sarcoma of femur after one year of radium and roentgen-ray treatment; the ivory-like appearance of the bone above the tumor, with resulting pathologic fracture, should be noted.

believed to be a metastatic tumor of the spine, which caused her death in a few months.

The original slide of the tumor, which was removed at the Boston City Hospital in 1899, was not preserved, so it is impossible to verify the diagnosis of round cell osteosarcoma which was made by Dr. F. B. Mallory, professor of pathology, Harvard Medical School.

Fig. 4 (case 1 in text).—Periosteal spindle cell sarcoma of shaft of tibia; recovery under prolonged toxin treatment followed by attack of accidental erysipelas; patient well twenty-eight years later.

Fig. 5 (case 4 in text).—Small round cell periosteal sarcoma involving two thirds of shaft of femur with metastases. The patient recovered under toxin treatment, and has been well for ten years.

CASE 3.—*Three times recurrent spindle cell sarcoma of metatarsal bone; amputation followed by toxins; inoperable; disappearance under toxins alone; patient well twenty-nine years later.*

F. K., a girl, aged 16 years, fell in 1888, injuring her right foot; shortly after a swelling appeared in the region of the injury and grew steadily until 1889, when the patient was operated on by Dr. William T. Bull at the New York Hospital, the third and fourth metatarsal bones being removed. Three years later she received another injury to the foot, which was followed by a prompt recurrence. A Symes amputation was then performed by Dr. Bull. In 1893 she fell down stairs, injuring the stump; shortly after, a lump appeared at the outer aspect of

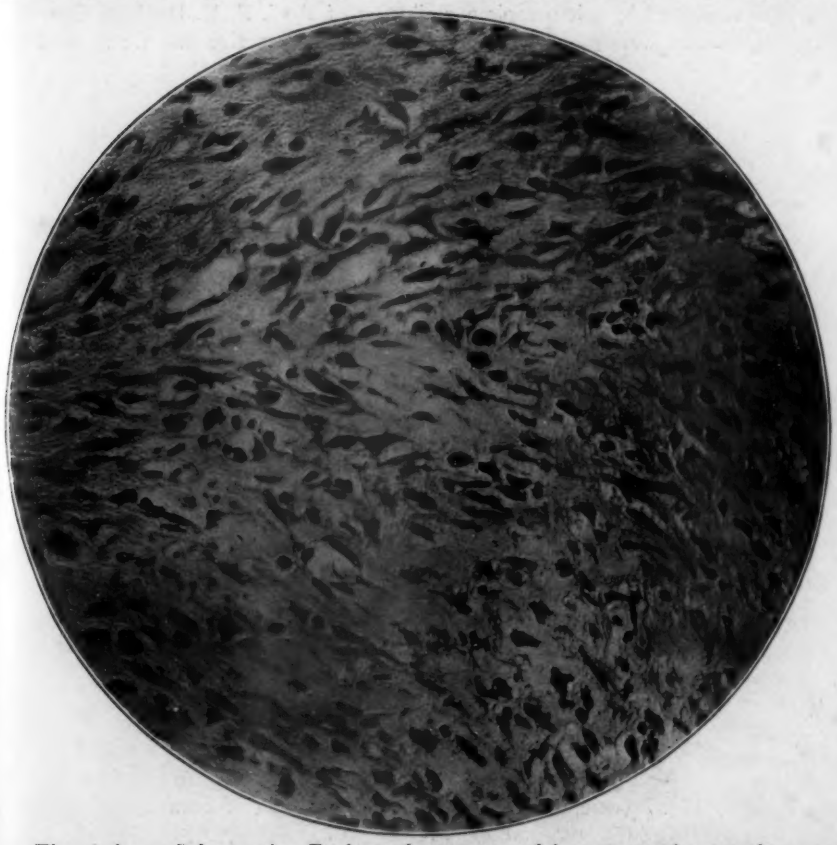

Fig. 6 (case 7 in text).—Periosteal sarcoma of humerus. Amputation was performed and toxins were administered; the patient has been well for fifteen years.

the stump, which slowly increased in size. Soon another tumor appeared in the popliteal space, which grew with great rapidity until December, 1893, when it had reached the size of a child's head. It was removed by Dr. Bull. The patient was then referred to us and put on the mixed toxins of erysipelas and *Bacillus prodigiosus* in January, 1894, under which treatment the tumor in the stump entirely disappeared. One and a half years later there was a recurrence in the stump, as well as in the popliteal region, and in 1896 we did a high amputation just below the trochanter; this was followed by a recurrence in the gluteal region. An incomplete operation was performed and the toxin treatment was resumed

and kept up with occasional intervals of rest for three years. The tumor disappeared; there was no further recurrence, and the patient was in excellent condition when last examined, twenty-nine years later.

CASE 4.—*Periosteal round cell sarcoma of femur, involving two thirds of shaft, with extensive multiple metastases; apparent cure by the mixed toxins of erysipelas and Bacillus prodigosus; well ten and one-half years, when a malignant tumor (sarcoma and epithelioma) developed in the thigh at the site of an old roentgen-ray dermatitis.*[21]

A. G., a man, aged 19, was referred to us in February, 1902, with a small round cell sarcoma involving two thirds of the shaft of the femur. The diagnosis had been confirmed by microscopic examination of Prof. E. K. Dunham, Bellevue Hospital Medical College. The involvement was so extensive that we advised an

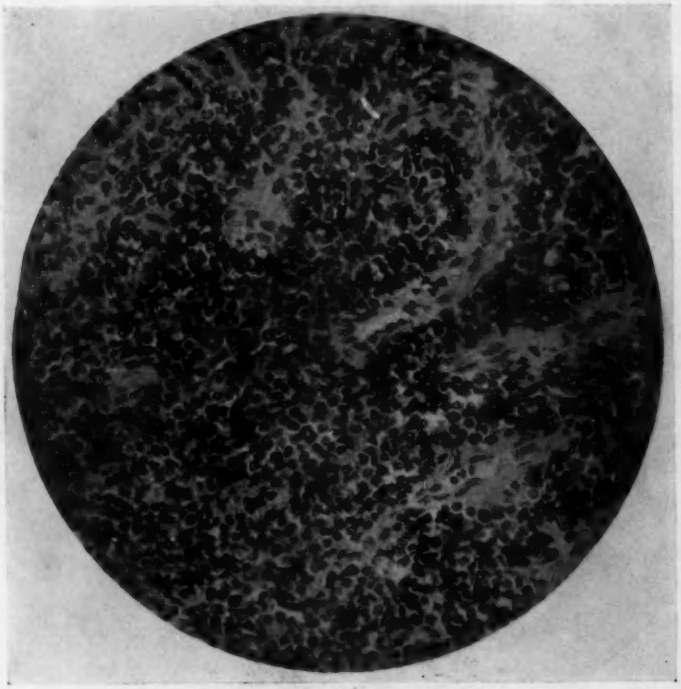

Fig. 7 (case 8 in text).—Periosteal sarcoma of femur.

immediate amputation; this the patient refused. During prolonged roentgen-ray irradiation an extensive metastatic tumor developed in the left pectoral region; this was removed surgically and the roentgen rays resumed. A second and larger metastatic tumor, the size of a child's head, appeared in the iliolumbar region, involving the ilium. This was treated by toxins alone; under six weeks' injections, it broke down and drainage was established by an incision made through the upper and posterior part of the ilium. The patient made a complete recovery with the exception of a persistent dermatitis which followed the irritation from the roenten rays, in the lower and anterior portion of the thigh. At the end of ten and one-half years this dermatitis suddenly took on signs of malignant degeneration; amputation was performed, Jan. 2, 1913; about two weeks later, the patient developed metastases in the lung and probably also in the peritoneum, and died January 16.

Previous to the amputation, we were fortunate in having been able to obtain from Dr. W. H. Welch, professor of pathology of Johns Hopkins Hospital Medical School, a complete pathologic report on a small recurrent tumor that had been removed from the thigh in April, 1912; his microscopic diagnosis was large round cell sarcoma. After amputation a full report of the specimen was made by Ewing. He found it difficult to interpret the exact type of tumor of the soft parts, but there was a definite epithelioma in the medullary cavity; this he regarded as a metastasis from the lesion of the surface caused by prolonged roentgen-ray treatment.[21] This tumor would undoubtedly now be classed by Dr. Ewing as an endothelioma. Unfortunately, the original slides have been lost.

Fig. 8 (case 9 in text).—Sarcoma of shaft of femur; clinical and roentgen-ray diagnosis, probably endothelioma; recovery under toxins alone; patient well twelve years later.

CASE 5.—*Periosteal round cell sarcoma of femur; amputation followed by prophylactic toxin treatment; patient well eighteen and one-half years later.*

J. P. W., a man, aged 35, had a negative family history. In the spring of 1906 he first felt pain in the right knee; this was treated for rheumatism for a number of months. He later came under the care of Drs. V. P. Gibney and John F. Erdman, with whom I saw the patient in consultation in September, 1906.

Physical examination at this time showed a tumor apparently of periosteal origin involving the whole lower end of the femur. An immediate amputation

followed by prophylactic toxin treatment was advised. An amputation 4 inches (10.1 cm.) below the trochanter was performed by Dr. Erdman, and the patient was then referred to us for toxin treatment. The injections were begun in Septemer, 1906, and kept up for four months. The patient made a good recovery, and has remained in excellent health up to the present time, eighteen and one-half years later.

A microscopic examination was made by Dr. F. E. Sondern, who reported round cell periosteal sarcóma. The slide in this case was later lost, so that it was impossible to register the case in the Bone Sarcoma Registry.

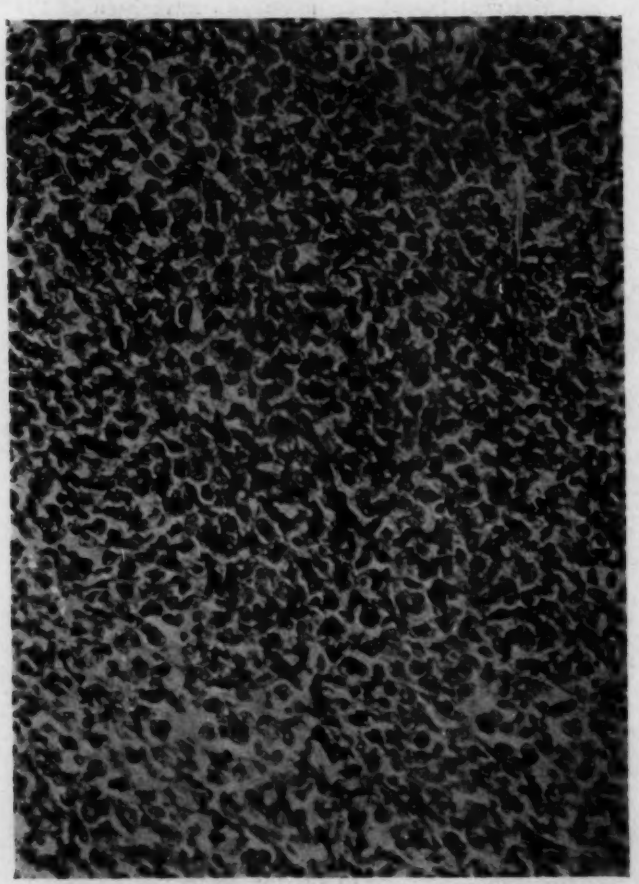

Fig. 9 (case 15 in text).—Osteogenic sarcoma of shaft of tibia with metastases in inguinal and iliac glands; radium and prolonged toxin treatment; limb saved; patient well nine years later.

CASE 6.—*Periosteal osteogenic sarcoma of femur; amputation followed by toxins one year; well eighteen years.*

Mrs. S., a married woman, aged 40, had always been well until the spring of 1908, when while dancing on a hard floor at St. Moritz, Switzerland, she slipped and fell, injuring her right knee; pain developed shortly afterward, and a in a few weeks the leg had greatly increased in size. She was first seen by us in consultation with Dr. A. D. Bevan of Chicago in the fall of 1908.

Physical examination at this time revealed a swelling of the lower end of the femur, firm in consistency but not of bony hardness; the knee joint was not involved. Roentgen-ray examination showed a tumor apparently of periosteal origin. The clinical and roentgen-ray diagnosis was sarcoma.

In view of the rapid growth and the extent of the involvement, we concurred in the opinion of Dr. Bevan that an immediate amputation should be performed; this was done in November, 1908. A microscopic examination was made by the

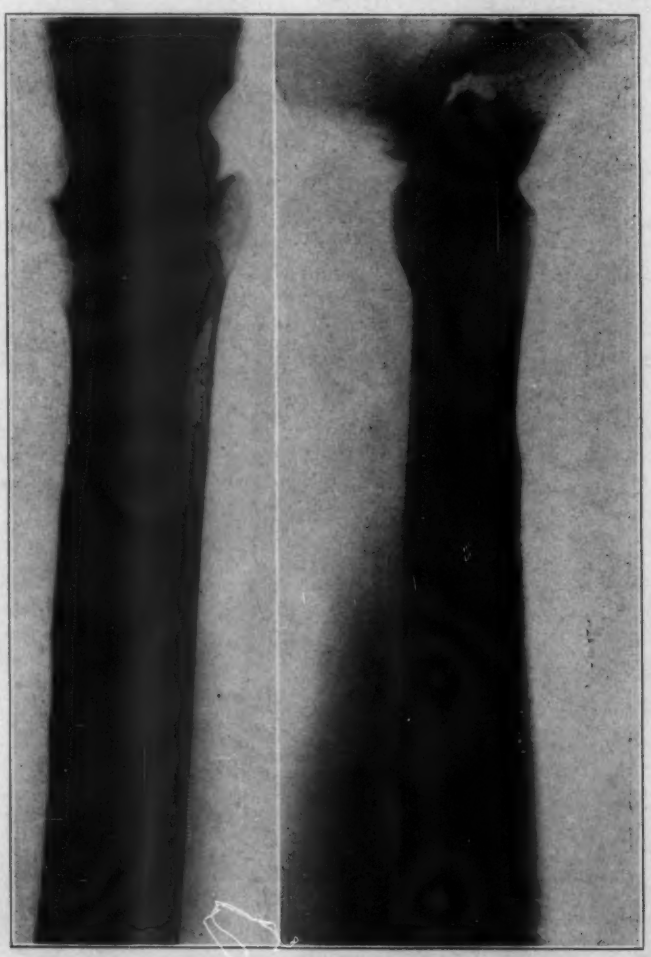

Fig. 10 (case 15 in text).—Five years after treatment.

pathologist of the Presbyterian Hospital, Chicago, and his diagnosis was periosteal osteogenic sarcoma. The diagnosis was confirmed by Ewing, and the case registered in the Bone Sarcoma Registry. As soon as the wound had healed the patient was put on the mixed toxins of erysipelas and *Bacillus prodigiosus,* and this treatment was continued by Dr. Lull of Oak Park, under our direction, for nearly a year. The patient was rather susceptible to the toxins and could never take more than 5 minims, which produced a fairly marked reaction.

The patient made a complete recovery and is well at the present time, seventeen years later.

CASE 7.—*Recurrent periosteal osteosarcoma of humerus; treated by toxins and roentgen ray; limb well at present, eighteen years later.*

We are indebted to Dr. John H. Gibbon, Philadelphia, for the following report: I. R., a girl, aged 17 years, was admitted to the Jefferson Hospital, Feb. 14, 1908. On the following day an operation was performed by Dr. Gibbon, who found a

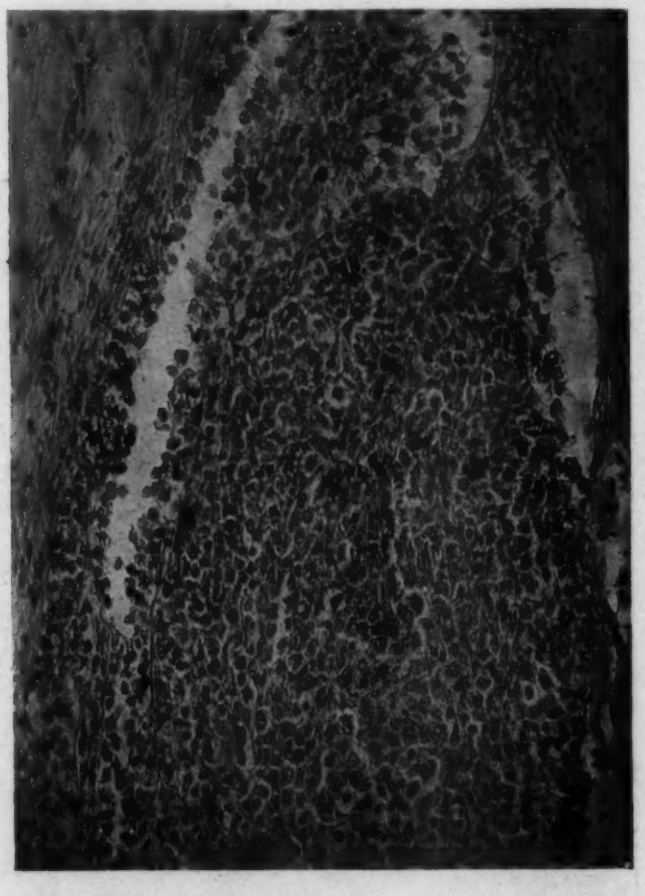

Fig. 11 (case 15 in text).—Section from inguinal node; metastatic sarcoma.

periosteal sarcoma with considerable infiltration of the muscular tissue; the whole mass was incised, the thickened periosteum was chiseled away, and the wound was left open with the intention of using roentgen-ray and toxin treatment in the event of amputation being refused. The patient was willing to have the amputation performed but her family would not consent to it.

The microscopic report of the pathologist of the Jefferson Hospital was that the growth was an osteosarcoma, with spindle cells predominating. A later microscopic report by Ewing stated: "The sections are quite small, being 10 by 1 mm. They show what appears to be a fibrosarcoma of periosteal type, but a positive

diagnosis is hardly warranted on account of the small size of the tissue examined. There is generally more stroma than cells, except in one focus where the cells are more numerous."

Examination, March 6, 1908, showed a distinct local recurrence involving the muscles. The patient was put on the mixed toxins supplemented by roentgen rays. Under the combined treatment the recurrence entirely disappeared, and the patient was shown before the Interurban Orthopedic Club, Nov. 4, 1910, in excellent condition. A recent letter from Dr. Gibbon states that the patient is still well, seventeen years later.[22]

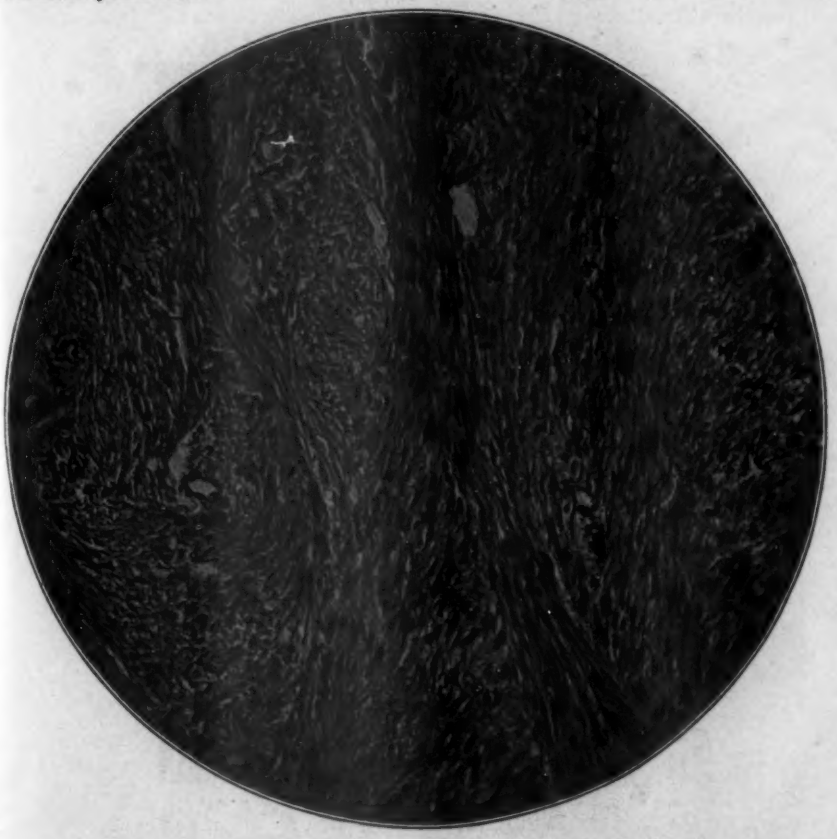

Fig. 12 (case 17 in text).—Periosteal osteosarcoma; no improvement under toxins and radium; amputation followed by toxins; well more than nine years later.

CASE 8.—*Periosteal sarcoma of femur; endothelioma; patient well sixteen years.*

This case is case 1 in Connor's article on endothelial myeloma, ARCHIVES OF SURGERY, April, 1926.

H. J., a man, aged 22, was operated on by Dr. John A. Hartwell at the Presbyterian Hospital in October, 1909, for a tumor of the femur. The microscopic report was round cell sarcoma. In December, 1909, he was referred to us

22. This case was reported in Ann. Surg. (Tr. Philadelphia S. Soc.), February, 1910, and also in the Bone Sarcoma Registry.

by Dr. Joseph A. Blake for toxin treatment, in the hope of saving the limb. Slight temporary improvement was noted, but a recurrence later took place, and we advised an immediate hip joint amputation, which was performed by Dr. Blake, December 23.

The microscopic report was: "The tumor is composed of medium size round cells packed together and supported by very little stroma. The tumor is vascular; the blood vessels lie in intimate contact with the cells; the cells radiate from the walls of the blood vessels in a manner that suggests their having originated from them. There are large spaces in the tumor which contain necrotic tissue and leukocytes. The diagnosis is round cell sarcoma (perithelioma)."

Fig. 13 (case 18 in text).—Periosteal osteogenic sarcoma of femur; amputation; postoperative toxins; patient well nine years.

The patient was again referred to us and received two periods of prophylactic toxin treatment at the Memorial Hospital during the winter and following spring. There has been no return of the tumor and the patient is in excellent condition at the present time, sixteen years later.

This case was reported in the Bone Sarcoma Registry under the Presbyterian Hospital series of cases. Ewing has recently reviewed the slide of the case and pronounced it an endothelioma.

CASE 9.—*Periosteal sarcoma of femur (clinical and roentgen-ray diagnosis); probably of the endothelioma type; recovery under toxins alone; well twelve years.*

This case is reported in full in *Annals of Surgery*, March, 1913.

Fig. 14 (case 19 in text).—Inoperable periosteal sarcoma of femur involving two thirds of shaft (1917); clinical and roentgen-ray diagnosis.

Fig. 15 (case 19 in text).—One year later than figure 14 after eight months' toxin treatment and one radium treatment.

Mrs. G. M., aged 27, had considerable tuberculosis in her family history. In May, 1912, the patient first felt pain in the right femur; this was treated for rheumatism for two months. Shortly after this a swelling developed at the same site, which slowly increased in size; there were no temperature and no signs of inflammatory trouble.

Physical examination at the time of our first observation, Sept. 19, 1912, showed a hard, fusiform enlargement apparently of bony origin occupying the upper and middle thirds of the right femur, gradually shading off into the normal outline of the bone; the tumor measured 8 by 7 inches (20.3 by 17.7 cm.); and at its largest circumference it measured 19¼ inches (48.8 cm.). The skin was normal. There was no vascular dilatation.

The patient had been examined by four surgeons, all of whom agreed on the diagnosis of periosteal sarcoma, and all of whom advised an immediate hip joint amputation. Although we concurred in the diagnosis, we believed it justifiable to

Fig. 16 (case 19 in text).—Seven and one-half years later than figure 15; patient now well eight and one-half years after treatment.

await the result of a brief course of toxin treatment before resorting to amputation. In order to verify the diagnosis, we performed an exploratory operation, Sept. 20, 1920; on cutting through the muscle we found a tumor apparently of periosteal origin, about three-fourths inch (1.8 cm.) thick; dissection revealed no evidence of pus or inflammatory tissue; the latter was mostly white, firm in consistency, and had all the typical macroscopic appearances of a periosteal sarcoma with little or no new bone formation. A microscopic examination was made by Ewing, who reported "the tissue shows very little if any specific process and does not permit of diagnosis. There is infiltration of the vessels with large round cells suggesting sarcoma, but which might very well be tuberculous." This same difficulty in making a positive diagnosis from microscopic sections had been noted in at least four of our cases which later proved to be sarcoma (endothelioma type).

The patient was immediately put on the mixed toxins of erysipelas and *Bacillus prodigiosus* without other treatment. The tumor at once began to decrease in size. Three months later the patient's condition was about the same; if anything, there was slight decrease in size of the tumor. A sinus persisted at the point of the original incision. While the patient showed no marked decrease in the circumference of the thigh, her weight increased a pound a week. The toxins were continued about six months.

Roentgen-ray examination made in March, 1913, showed the bone apparently much more dense than at the time of the previous examinations, as though the tumor tissue had been replaced by normal bone. By September, 1913, the patient

Fig. 17 (case 20 in text).—Periosteal sarcoma of tibia; diffuse endothelioma (Ewing); well eight years after amputation followed by prolonged toxin treatment.

had gained 21 pounds (9.5 Kg.) in weight. The measurements were the same on both sides; her general condition was excellent, and she had no pain. The patient was in excellent condition when last traced, twelve years later.

Here we believe that the clinical, roentgen ray and microscopic evidence point almost conclusively to a diagnosis of endothelial type of tumor of the shaft of the femur. It is interesting to note that the disease was completely controlled by the toxins alone without radiation. The clinical history, roentgengram and macroscopic appearance of the tumor on exploratory operation closely resembled other cases of the endothelioma type of sarcoma of the long bones.

Fig. 18 (case 21 in text).—Metastasis to skull following amputation for periosteal sarcoma of femur one and a half years before.

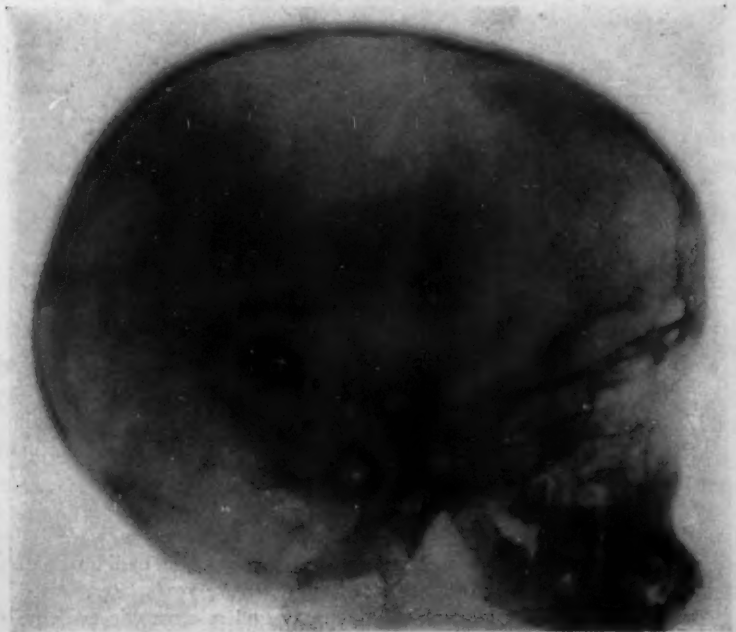

Fig. 19 (case 21 in text).—Four years later than figure 18; marked regeneration of bone. The patient is now well, seven and one-half years later.

CASE 10.—*Periosteal osteogenic sarcoma of femur; amputation followed by prolonged prophylactic toxin treatment; patient well twenty years later.*

S. D., a girl, aged 18 years, had a negative family history. In the beginning of 1905, the patient first noticed pain in the right knee; this continued until August of the same year, when a plaster splint was applied at St. Luke's Hospital. The condition at that time was regarded as of tuberculous origin. The splint was worn for nearly seven months. March 29, 1906, the patient was admitted to the Hospital for Ruptured and Crippled, in Dr. V. P. Gibney's service. During the preceding two months she had been confined to bed and was in an emaciated and extremely weak condition.

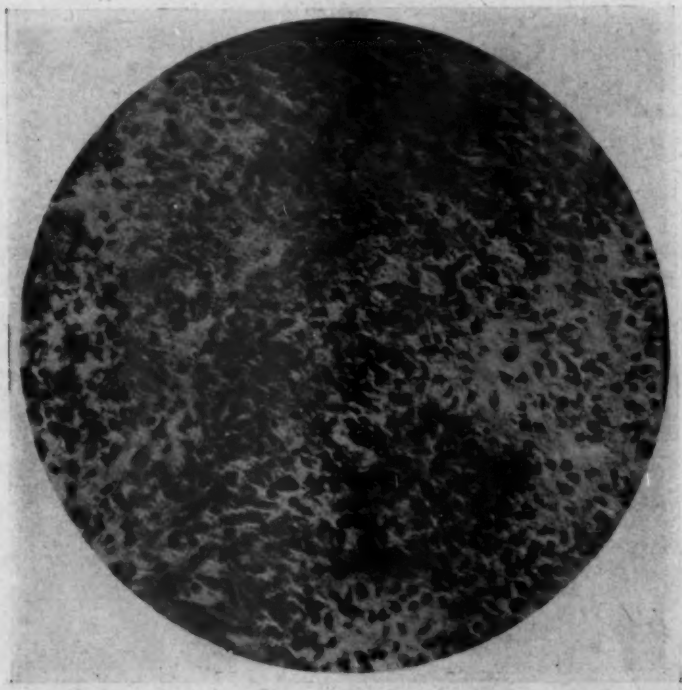

Fig. 20 (case 21 in text).—Specimen classified as endothelioma by Ewing and as round cell sarcoma by other pathologists; patient well nearly seven years later.

Examination of the right knee showed a fusiform swelling just above the joint; the circumference of this knee was nearly 5 inches (12.7 cm.) greater than that of the opposite one. Roentgen-ray examination at this time showed the lower 6 inches (15.2 cm.) of the femur nearly twice the normal thickness.

An exploratory operation was performed by Dr. Gibney and one of us, revealing what was believed to be a sarcoma. In view of the extent of the involvement an immediate amputation was advised, and performed 4 inches (10.1 cm.) below the trochanter, April 7. The patient was then put on the mixed toxins, the injections being increased up to the point of producing marked reactions. She almost immediately began to gain in weight, rising from 69 pounds (31.3 Kg.), June 12, to 92 pounds (41.7 Kg.), October 24. She has remained in good health up to

the present time, and was shown before a special bone clinic at the Memorial Hospital in April, 1925, nineteen years later.

The diagnosis made by Dr. Jeffries, pathologist to the Hospital for Ruptured and Crippled, in this case was osteosarcoma, mixed cell (no giant cells). The slide has been recently reviewed by Ewing and pronounced malignant osteogenic sarcoma. The case has been registered in the Bone Sarcoma Registry.

CASE 11.—*Periosteal sarcoma of ulna; amputation followed by toxins; patient well seventeen years later.*

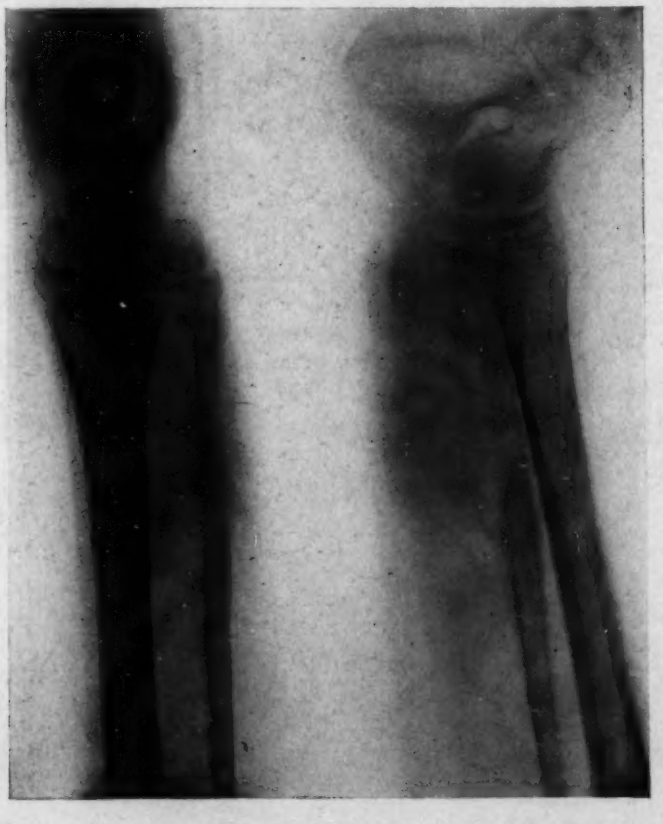

Fig. 21 (case 12 in text).—Periosteal sarcoma of fibula; endothelioma; extensive metastases to femoral, iliac and inguinal glands as well as to lung; amputation followed by toxins and radium; patient well six years later.

E. M. I., a boy, aged 15 years, with a negative family history, early in July, 1908, came under the care of Dr. Robert M. Lovett, Boston, with the history that he had slipped on an oiled floor in the school room, fracturing and dislocating the elbow; this was reduced two hours later; four days later the arm was reset. Seven months later he began to have pain at the site of the fracture; a tumor developed and grew rapidly. Roentgen-ray examination showed an extensive tumor of the upper half of the ulna. An amputation of the arm was performed by Dr. Lovett in July, and the patient was immediately referred to

us for toxin treatment. The injections were carried out at home by the local physician under our direction; they were given every other day for a period of three months; the final dose, 5½ minims, was given October 9; a severe reaction followed. The patient has remained in good health up to the present time, seventeen years after the amputation was performed.

A microscopic examination was made by Dr. Whitney of the Harvard Medical School, who reported round cell sarcoma. Since Dr. Whitney's death his specimens have been scattered and it has been impossible to obtain a slide for verification of the diagnosis. This case has been registered in the Bone Sarcoma Registry as a giant cell sarcoma, but the clinical history and the roentgenograms, together with

Fig. 22 (case 22 in text).—Metastases in lung.

Dr. Whitney's microscopic report, incline us to believe that it should be classed as a sarcoma of the endothelioma type.

CASE 12.—*Periosteal spindle cell sarcoma of the right forearm and radius.*

K. W., a girl, aged 16 years, was referred to us by Dr. George H. Monks, Boston, April 7, 1913, with the history that five years before the patient had twisted her right forearm violently while at play; one year later a swelling appeared 2 inches (5 cm.) above the wrist joint. During the next year she received a short course of roentgen-ray irradiation at the Massachusetts General Hospital. The tumor continued to increase in size, and she was seen by Dr. Monks in January, 1913, when a diagnosis of sarcoma was made, and amputation advised. The tumor at that time was 9½ inches (24 cm.) at its greatest circum-

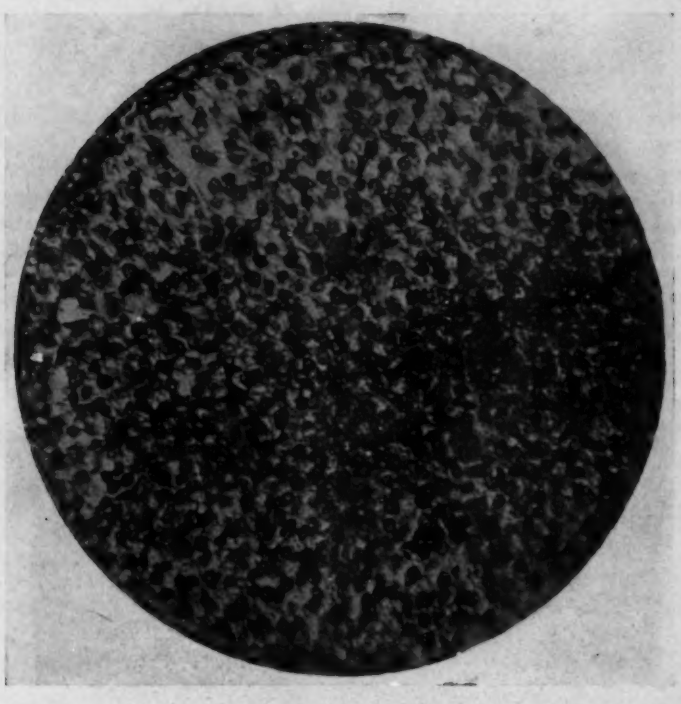

Fig. 23.—Specimen from case 12 in text.

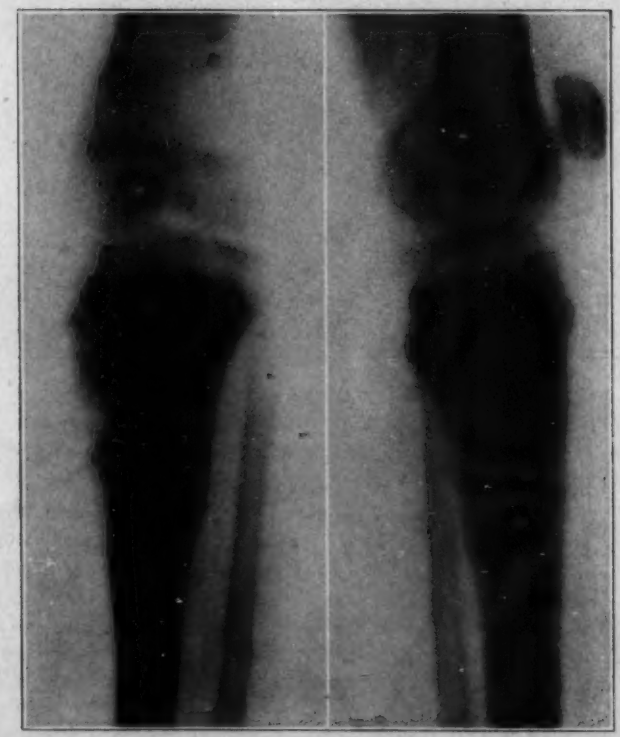

Fig. 24 (case 24 in text).—Sarcoma of tibia. Amputation was performed and toxins were given. The patient was well five years later.

ference, and apparently involved the lower portion of the radius and ulna; it was uniform in contour and slightly tender over its entire surface, with occasional areas in which an indefinite sense of fluctuation could be made out. She was treated for three months at Grace Hospital, without improvement, and later was treated at the Homeopathic Hospital for nine weeks, without improvement.

Physical examination at the time of our first observation showed a fusiform swelling of the lower end of the ulna and radius, beginning at 1½ inches (3.7 cm.)

Fig. 25 (case 24 in text).—One month later than figure 24.

above the lower end of the radius and extending up 5 inches (12.7 cm.), entirely surrounding the forearm. Extension of the fingers was limited; the skin was markedly discolored.

The patient was put on the mixed toxins; twenty injections in all were given, two-thirds systemically and one-third locally. There was no improvement. A roentgen-ray examination was made by Dr. A. F. Holding, who reported sarcoma, apparently periosteal, of the ulna, and deformity and atrophy of the radius. In view of the roentgen-ray and clinical observations, we decided that it was unwise to try conservative treatment any longer, and therefore, May 5, 1913,

we amputated the arm at the upper third. The toxins were resumed after the operation, and were given for a considerable period of time at home.

The microscopic diagnosis of Ewing was periosteal spindle cell sarcoma. The case is registered in the Bone Sarcoma Registry.

The patient made a good recovery, she gained considerably in weight, and was in excellent condition with no evidence of a recurrence when last heard from, thirteen years later.

CASE 13.—*Sarcoma of humerus.* M. K., a man, aged 51, with a negative family history, had no history of trauma. He had the ordinary diseases of child-

Fig. 26 (case 24 in text).—Sarcoma of tibia.

hood; had gonorrhea at 31, but no history of syphilis. In 1913 the patient was admitted to the Nassau County Hospital, where a suprapubic operation was performed on account of an attack of retention of urine; this was accompanied by a high fever, during which the patient's right arm suddenly became paralyzed; he was in bed for eighty-one days. April 12, 1915, the patient was admitted to the Memorial Hospital, to the service of Dr. W. A. Downes. He was treated for a year and a half with roentgen-ray irradiation for a condition of the right shoulder which was supposed to be sarcoma, based on the clinical diagnosis of Dr. L. A. Stimson, and supported by roentgen-ray examination. The condition slowly improved. After leaving the Memorial Hospital, the patient developed a

roentgen-ray burn over the shoulder; this resisted all palliative treatment. He was admitted to the City Hospital, April 18, 1917, where he was operated on by Dr. Nathan W. Green, who resected the head of the humerus, head of the scapula and outer end of the clavicle. The wound was slow in healing on account of the traumatism caused by the roentgen-ray therapy.

The microscopic diagnosis of Dr. Larkin of the Strecker Memorial Laboratory was small spindle cell sarcoma.

The patient made a good recovery, and in a letter dated January, 1925, he wrote that he was in excellent condition.

Fig. 27 (case 26 in text).—Periosteal osteogenic sarcoma of femur; popliteal region; amputation plus toxins; well five years.

The peculiar early clinical history lends itself to the possibility that the original trouble in the humerus was an osteitis or osteomyelitis and that the sarcoma found at the operation one and one-fourth years later developed on the old roentgen-ray burn.

CASE 14.—*Periosteal spindle cell sarcoma of the metatarsal bone; amputation followed by prophylactic toxin treatment; patient well when last traced, ten years later.*

E. W. M., a woman, aged 22, with a negative family history had no definite history of injury. In June, 1901, the patient first noticed pain, and a slight swell-

ing in the dorsum of the right foot developed soon after. The pain increased in severity, requiring morphine. She was treated for a number of weeks for rheumatism. One of us first saw her in consultation with Dr. Alexander Lambert in August, 1901. The clinical diagnosis was periosteal sarcoma. An immediate amputation was advised, which, three days later, one of us performed at the junction of the middle and lower thirds of the tibia. On microscopic examination the tumor proved to be a spindle cell periosteal sarcoma. Shortly after the operation the patient was put on prophylactic toxin treatment which was kept up for eight months. Examination ten years later showed her in excellent condition with no evidence of a recurrence.

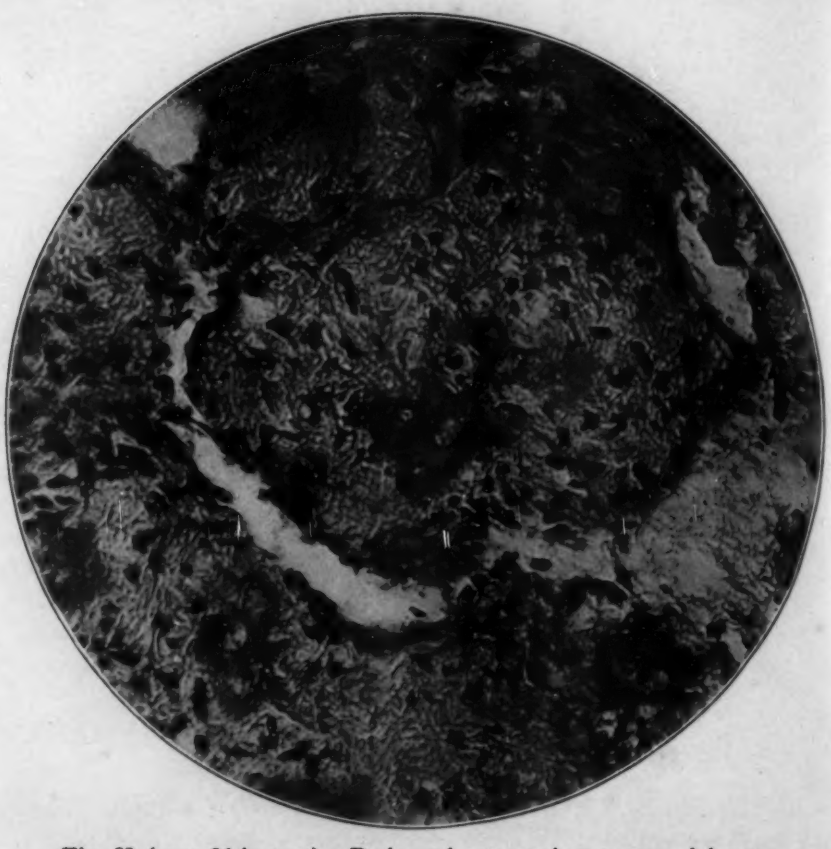

Fig. 28 (case 26 in text).—Periosteal osteogenic sarcoma of femur.

CASE 15.—*Periosteal osteogenic sarcoma of tibia with extensive inoperable metastases in the femoral, inguinal and iliac glands; complete recovery under toxins and radium treatment; limb saved; patient well nine years later.*

C. H. S., a man, aged 39, was referred to us by Dr. John H. Gibbon of Philadelphia in the latter part of April, 1917, with a history of a rapidly growing tumor of the shaft of the left tibia of six weeks' duration. Dr. Gibbon and several other surgeons regarded it as a periosteal sarcoma. We concurred in the diagnosis but in order to confirm it, we did an exploratory operation, removing a piece of the tumor. This was turned over to Dr. James Ewing for examination,

and he pronounced it a highly malignant osteogenic sarcoma. We decided to try conservative treatment for a while instead of amputating immediately, and started him on the mixed toxins of erysipelas and *Bacillus prodigiosus* combined with radium treatment. From May 1 to July 19 he received 46,720 millicurie hours of radium over the tibia. The toxins were kept up at home by his physician, Dr. R. G. Gamble. In the middle of August, the patient asked permission to go to the seashore for a month; as physical examination at this time failed to reveal any evidence of the disease remaining, we decided that it would do no harm to discontinue the toxins for a few weeks. The patient returned to us in the early part of October.

Fig. 29 (case 29 in text).—Sarcoma of upper end of humerus with metastases in lung, diagnosed clinically and by roentgen ray. Toxins were administered; the patient recovered, and has been well for six years.

Examination at this time showed extensive metastases in the inguinal, femoral and iliac glands, some of which were an inch (2.5 cm.) or more in diameter. We gave a hopeless prognosis but decided to try the treatment a little longer. The radium pack was applied over the glands of the groin in October (18,000 millicurie hours), in November (17,270 millicurie hours) and in December (12,000 millicurie hours). At the same time, the toxins were resumed and kept up with occasional intervals of rest for two and a half years, in doses not sufficient to interfere with the patient's daily routine of life. All evidence of the disease disappeared as shown by later roentgen-ray and physical examinations. The patient is alive

and well at the present time, July, 1926, with a useful limb, nine and a quarter years later.

This is one of the few cases on record of a periosteal osteogenic sarcoma with metastases that has been cured by any method of treatment; it has been included in the Bone Sarcoma Registry as one of the thirteen cases (up to October, 1924) of periosteal sarcoma in which the clinical, roentgen-ray and microscopic diagnosis has been passed on by the committee which has remained well for five years, and the only one in which the limb was saved.

CASE 16.—*Periosteal sarcoma of lower end of femur; treated with prolonged radiation and toxins, without control; amputation followed by prolonged toxin treatment; well nine years later.*

Fig. 30 (case 29 in text).—Four years after treatment; no metastases present.

W. P., a married woman, was admitted to the Memorial Hospital, Feb. 15, 1917. She had had a stiff knee for one year, and had lost weight. There had been gradual increase in size with almost complete loss of motion in the joint, until it was 1 inch (2.5 cm.) larger than normal in circumference. She consulted Drs. George E. Brewer and George D. Stewart of New York, both of whom advised an immediate amputation. She then consulted Dr. J. M. T. Finney of Baltimore, who advised radium; this treatment was carried out at Dr. Howard Kelly's Hospital at Baltimore by Dr. C. F. Burnam from Oct. 23, 1916, to January, 1917, as follows: Oct. 23, 1916, 3,308 mg. for fourteen hours; October 29, 934 mg. for seventeen hours; November 15, 3,364 mg. for eleven hours; November 29, 100 mg. for fourteen hours; December 14, 1,392 mg. for twelve hours, and Jan. 11, 1917, 618 mg. for thirteen and one-half hours.

There was little if any improvement from the radium. The patient returned to Dr. Finney in January, 1917, and he operated, chiseling a portion of the periosteum from the outer aspect of the femur. The diagnosis was periosteal sarcoma.

The wound healed by primary union and the patient was then referred to us for toxin treatment. For five months she was treated with injections of the mixed toxins supplemented by one radium treatment in the form of a pack (7,200 millicurie hours at 5 cm. distance). There was little benefit noted and, July 6, 1917, we amputated the limb, following this with prophylactic toxin treatment.

On microscopic examination Ewing reported a periosteal osteogenic sarcoma of the sclerosing type.

The patient made a good recovery and has remained in excellent condition up to the present time, nine years later. This case was reported in the Bone Sarcoma Registry.

Fig. 31 (case 32 in text).—Extensive sarcoma of upper third of femur with marked destruction of bone (clinical and roentgen-ray diagnosis); probably endothelioma. Recovery was made under toxins alone; the patient has been well for five years.

CASE 17.—*Osteosarcoma of femur.* G. T., a woman, aged 26, with a negative family history, in May, 1915, fell, injuring her left knee. The next morning she noticed a small swelling on the outer part of the thigh; this remained unchanged during the following year. Feb. 24, 1916, she again fell, injuring the same leg, and soon after noticed a tumor on the inner side of the thigh near the knee; this steadily increased in size; it was not associated with pain.

Physical examination at the time of our first observation, June 20, 1916, showed a hard, bonelike tumor, beginning at the middle of the popliteal space

and occupying the whole posterior surface of the thigh, measuring 4 inches (10.1 cm.) in diameter and extending upward 5 inches (12.7 cm.). The tumor was extremely hard in consistency, markedly protuberant, and with broad attachment to the femur. The roentgenograms showed a typical periosteal sarcoma of the osteoid type occupying the posterior lateral surface of the femur just above the lower end. During the first three weeks of July, 1916, the patient was treated with systemic injections of the mixed toxins, seven in all, supplemented by the radium pack, 4,000 millicurie hours, applied over three different areas, July 4, and a similar treatment, July 9, making a total of 24,000 millicurie hours of

Fig. 32 (case 32 in text).—Femur at time of injury showing no tumor or pathologic condition.

radium. As there was no apparent improvement noticed under conservative treatment, we amputated the leg, August 20.

The microscopic report of Ewing stated: "The section shows a spindle cell sarcoma inclosing many well formed trabeculae of bone. The spindle cells are well formed, long, slender, and are supported by considerable fibrous stroma. The tumor is to be classed with the fibrosarcomas in malignancy, which appears to be much less than in the usual bone sarcoma." A previous report by Ewing, based on a microscopic examination of a specimen removed on exploratory incision, reads as follows: "The section shows chronic osteitis but no tumor. The tissue

is composed of many irregular trabeculae of well formed bone, lying in loose new connective tissue. New bone formation is not active."

The mixed toxins were resumed after the amputation, and kept up for a considerable period. The patient was examined by one of us eight and one-half years later, at which time she was in excellent condition.

CASE 18.—*Periosteal osteogenic sarcoma of femur; amputation at hip joint followed by prolonged toxin treatment; patient well ten years later.*

J. H. F., a man, aged 48, was referred to us by Dr. David Barrow of Lexington, Ky. At the age of 4, the patient fell, sustaining a fracture of the right femur at about the middle. At the age of 11, he again fractured the same femur; he made a good recovery with normal function. At the age of 21, he had a slight periostitis at the site of the old fracture; no operation was performed, and he

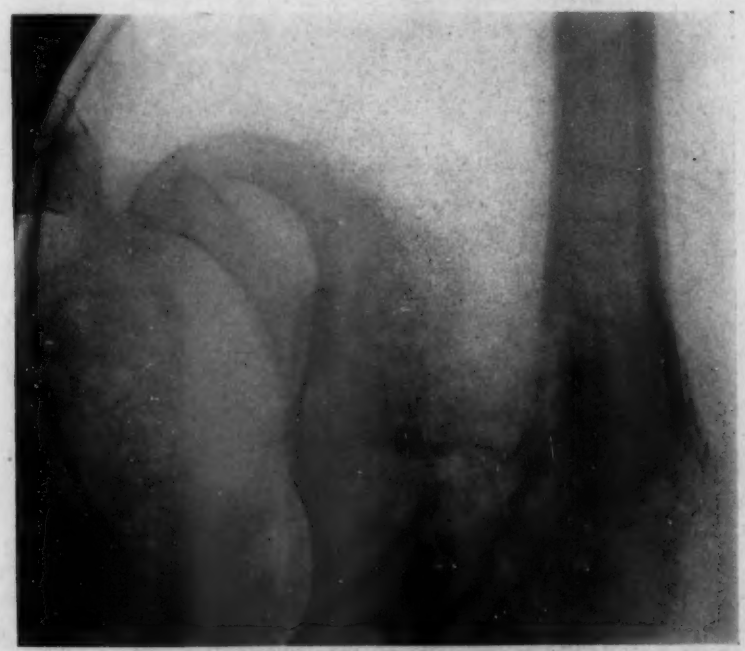

Fig. 33 (case 32 in text).—Femur after three months' toxin treatment; patient well five years later.

remained well until June, 1916, when he noticed enlargement at the site of the old fracture accompanied by considerable pain and increasing disability. In August, 1916, a local operation consisting in curettage was performed, followed by roentgen-ray treatment (eight exposures). Temporary improvement followed this treatment but the tumor later again began to increase in size.

Physical examination at the time of his admission to the Memorial Hospital, Oct. 16, 1916, showed about 3½ inches (8.8 cm.) below the trochanter of the right femur, a hard, firm tumor covering the outer and anterior aspects of the leg from Hunter's canal downward for about 6 inches (15.2 cm.), extending around the femur for a distance of three-fourths of the circumference. There was an old cicatrix 8½ inches (21.5 cm.) long, the central portion of which was occupied

by an area of ulceration. There was slight dermatitis over the tumor, probably due to the roentgen-ray treatment. The course of the cictarix was markedly indurated. The right thigh was atrophied. The tumor was fusiform in outline, firmly fixed to the femur, and apparently originated from it.

A roentgenogram, Oct. 19, 1916, showed extensive localized destruction of the femur, not, according to Dr. Herendeen, characteristic of periosteal sarcoma. There was thickening and fibrosis at the hila of the lungs but no evidence of metastasis nor of parenchyma; there was evidence of tuberculosis in the left lung. The patient was immediately put on the mixed toxins of erysipelas and *Bacillus*

Fig. 34 (case 34 in text).—Clinical diagnosis: osteomyelitis; roentgen-ray diagnosis: endothelioma; no microscopic examination; recovery under toxins.

prodigiosus, supplemented by radium, 2,000 millicurie hours at 2 cm. distance. After two weeks' treatment, little improvement having taken place, a hip joint amputation was performed, October 31, by one of us. The toxins were resumed shortly after and continued by Dr. Barrow at home for a number of months. A microscopic report by Ewing read: "Large spindle and giant cell sarcoma. The structure resembles myosarcoma and not the usual bone sarcoma. The spindle cells are long, and the cytoplasm is very acidophil. The giant cells are mononuclear." A slide was later submitted to Dr. Francis Carter Wood, who pronounced it a spindle cell osteogenic sarcoma.

The patient is alive and well at the present time, nine years later. This case has been reported in the Bone Sarcoma Registry.

CASE 19.—*Periosteal sarcoma of femur (clinical and roentgen-ray diagnosis) involving upper half of femur; inoperable; treated by toxins and radium; well nine years; limb saved.*

R. H., a man, aged 36, with a negative family history, in January, 1917, fell on the ice, fracturing his left femur just below the trochanter. Roentgen-ray examination by Dr. George Hawley of Bridgeport, Conn., showed no evidence of a pathologic condition. Nine weeks later, a swelling developed at the site of the

Fig. 35 (case 34 in text).—Fourteen months later than figure 34.

injury and continued to increase in size. The patient remained in St. Vincent's Hospital in Bridgeport for twenty-seven weeks, after which he was referred to Dr. L. Fischer of the Lenox Hill Hospital, who in turn sent him to me.

Physical examination at the time of his admission to the Memorial Hospital, October 20, showed a huge tumor occupying the upper two thirds of the femur, apparently periosteal in origin, pathologic fracture and almost complete destruction of 5 inches (12.7 cm.) of the shaft; the circumference was 64 cm. The condition was considered entirely beyond hip joint amputation; 5 inches of the shaft had been destroyed. Roentgen-ray examination showed probable metastases of the lungs. From 1917 to June, 1918, he received local and systemic injections

of the mixed toxins; in addition, the radium pack (about 40,000 millicurie hours at 10 cm. distance) was applied in November, and again in December. The circumference of the leg diminished 8 cm.; there was some union of the pathologic fracture; roentgen-ray examination of the chest was negative. A Thomas splint was applied, and the patient returned home. He has remained in excellent condition, and was shown before the members of the Clinical Congress of Surgeons

Fig. 36 (case 35 in text).—Osteogenic sarcoma after four months' treatment with toxins and roentgen rays; patient gained 17 pounds (7.7 Kg.) in weight; circumference of thigh normal. The patient remained well for one and a half years, then developed a nodule in lung.

in October, 1925. Since January, 1919, he has been able to walk without a crutch or a cane; the only thing he has to wear is an orthopedic shoe, on account of the 5 inches shortening caused by the complete destruction of bone. He has been well for nine years.

Fig. 37 (case 49 in text).—Endothelioma of os calcis.

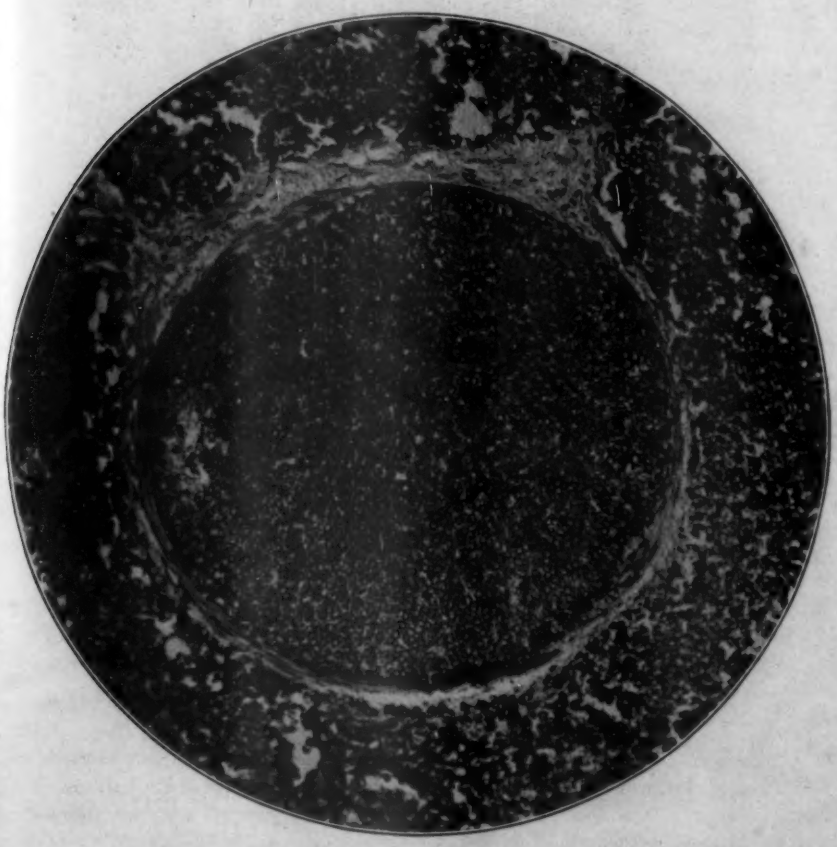

Fig. 38 (case 49 in text).—Endothelioma of os calcis.

CASE 20.—*Periosteal sarcoma of tibia.* R. W., a girl, aged 7 years, was referred to us by Dr. F. N. G. Starr of Toronto in June, 1917. There was no previous history of trauma. In December, 1916, the patient first noticed a swelling in the midshaft of the right tibia; this continued to increase in size. A number of roentgen-ray treatments were given in January, 1917, in Toronto, with temporary improvement. Roentgen-ray examination of the chest showed a number of apparent metastases of the lungs, although on this point one could not be absolutely certain.

Fig. 39 (Ewing's case).—Specimens from patient 49 in text.

Roentgen-ray examination at the time of her admission to the Memorial Hospital, June 20, also showed probable lung metastases; therefore, three prophylactic roentgen-ray treatments over the chest were given while she was in the hospital. The toxins, which were started in June, were kept up until July 16, 1917, when in view of the fact that there was no marked improvement an amputation was performed at the middle lower third of the thigh. It is interesting to note

Fig. 40 (case 19 in table 7).—Endothelial myeloma of femur with metastases in spine.

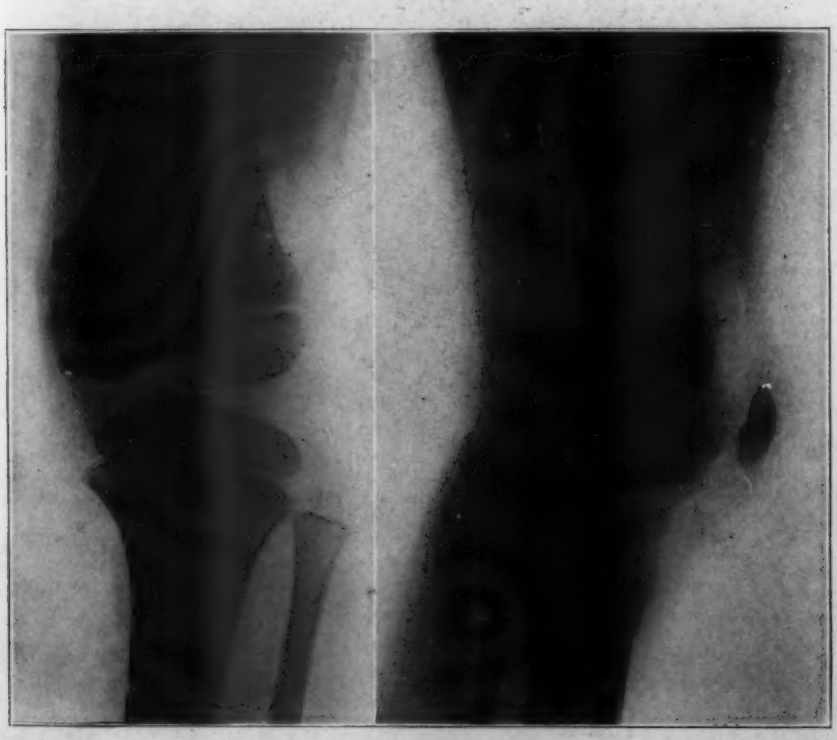

Fig. 41 (case 42 in table 7).—Central malignant sarcoma of femur.

that the patient had an occasional temperature of 102 before the toxin treatment was given; this is one of the rare cases of sarcoma of the long bones associated with marked temperature. The tumor was apparently of periosteal origin with very extensive involvement of the greater portion of the shaft of the bone.

A microscopic examination was made by the pathologist of Toronto General Hospital, whose diagnosis was round cell periosteal sarcoma. The amputated leg specimen was examined by Ewing also, who reported diffuse endothelioma.

Fig. 42 (case 42 in table 7).—Two and one-half months later than figure 41. The patient developed metastases after amputation.

The toxin injections were resumed a few days after the amputation and continued for nearly six months after the patient left the hospital. She has remained in good health up to the present time, eight years later.

CASE 21.—*Periosteal sarcoma of femur with multiple metastases in skull.* W. L. B., a boy, aged 6 years, when about 3 years old, in 1916, fell from a pony;

a tumor developed in the upper third of the shaft of the femur. This grew rapidly, and in August, 1917, an amputation was performed by Dr. Stuart McGuire of Richmond, Va. The microscopic diagnosis was periosteal sarcoma of the round cell type with no giant cells.

In October, 1918, he first noticed a swelling in the right parietal bone, and beginning exophthalmos; there was a softened area of the skull, which steadily increased in size. At the time of my first observation in June, 1919, there was a depressed area occupying nearly the whole right parietal region and apparent absence of bone over the area, 2 by 3 inches (5 by 7.6 cm.) in size; pulsation was easily felt; there was marked exophthalmos. Roentgen-ray examination by

Fig. 43.—Central malignant osteogenic sarcoma of tibia; exploratory operation followed by prolonged toxins; limb saved; patient well four years later.

Dr. Quick showed destruction of both tables of the skull over the midparietal region, and an extensive intracranial tumefaction beneath which strongly suggested a cyst. A hopeless prognosis was given, but a trial with the mixed toxins was advised as a palliative measure. The toxins were begun June 6, 1919, in doses ranging from one-fourth to 3 minims; thirteen injections in all were given at this period; marked reactions were obtained. The injections were then continued at home. In addition, the patient received two radium pack (lead tray) treatments over the right temporal and frontal regions (total of 12,847 millicurie hours) at 3 cm. distance. He was readmitted to the Memorial Hospital, Aug. 6, 1919, at which time the exophthalmos was found to have nearly disappeared, and the

tumor mass in the brain was barely palpable. Two radium pack (lead tray) treatments were given over two areas of the right temporal region (total of 5,867.2 millicurie hours) at 30 mm. distance. October 2, another radium pack was applied over the right temporal region (2,940 millicurie hours). March 2, 1920, the lead tray was applied over two areas, the right parietal and the supraorbital regions (2,992 millicurie hours each). Roentgen-ray examination

Fig. 44 (case 67 in table 7).—Central malignant sarcoma of tibia simulating giant cell sarcoma.

at this time failed to reveal any palpable tumor; the bulging of the eye was slight. The patient's general condition was excellent. In the latter part of April, 1920, he developed a similar tumor with marked bone destruction in the occipital region, 1 by 2 inches (2.5 by 5 cm.) in diameter and easily shown by the roentgen rays. According to Dr. Herendeen, the roentgenograms of the skull revealed evidence indicating further bone formation in areas previously involved in the

destructive process. From July 8, 1920, until Aug. 9, 1921, the patient received further radium treatment in the form of the lead tray over the parietal, occipital and temporal regions (total of 24,477 millicurie hours, 3 cm. distance).

Physical examination, April 27, 1922, showed the patient in excellent general condition; there was only slight exophthalmos of the right eye; the sight was normal; the large area in the right parietal region which was originally almost

Fig. 45 (case 73 in table 7).—Sarcoma of fibula; resection; amputation; followed by lung metastases.

completely destroyed was almost entirely filled in with new bone; the occipital region also was normal. He had been attending school all winter and had made two grades. He was given another radium treatment at this time, more as a prophylactic measure than anything else. The toxins had been kept up with occasional intervals of rest, since the time of my first observation. The improvement was continuous, the patient gained in weight, and at the present time,

July, 1926, he is in excellent condition with no evidence of any return of the old trouble (seven years later).

Ewing reviewed a slide of this tumor, and was inclined to regard it as an endothelioma or endothelial myeloma.

This patient was shown before the American Surgical Association, at Washington, D. C., May, 1925, and is still well, November, 1926, seven and one-half years after treatment was begun.

CASE 22.—*Periosteal sarcoma of fibula with metastases in groin, abdomen and lungs (Endothelioma, Ewing); amputation, toxins and one radium treatment. The patient has been well for six and one-half years.*

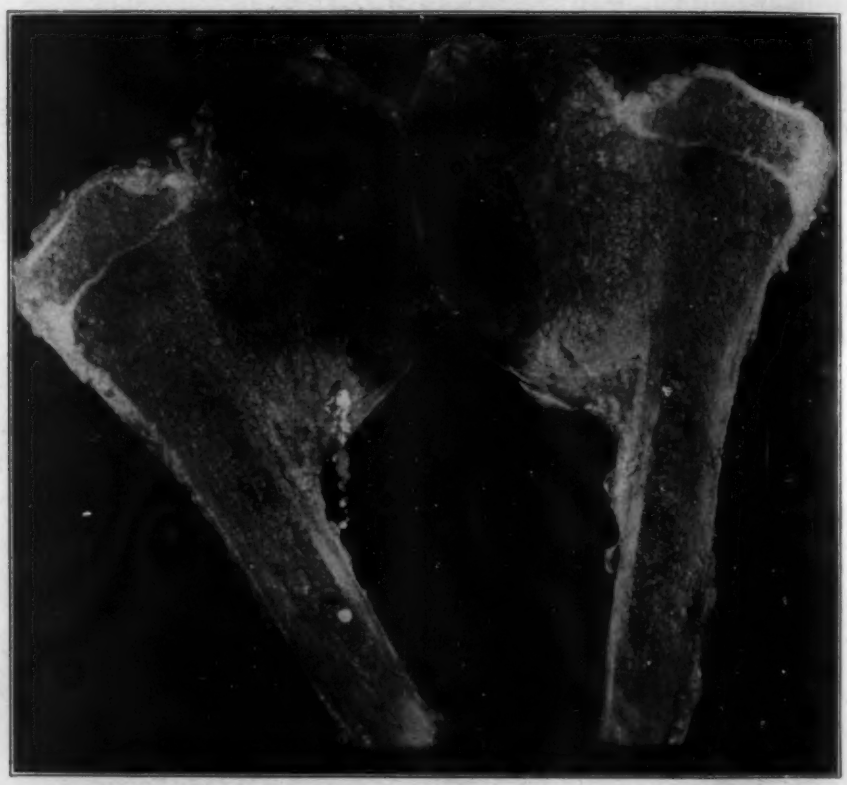

Fig. 46 (case 78 in table 7).—Periosteal osteochondrosarcoma of tibia. Roentgen-ray treatment was given for six weeks; amputation was followed by toxins. The patient died from metastases four months later.

H. S., a boy, aged 8 years, with a negative family history, had always been well until January, 1920, when he was struck on the outer side of the right leg; shortly after he began to have pain in the leg, and a few days later a swelling developed; this apparently was of bony origin. The swelling increased in size and in March, 1920, an operation was performed at the Hospital for Ruptured and Crippled by Dr. Royal Whitman. The clinical and roentgen-ray diagnosis was osteomyelitis.

An exploratory operation showed some pus and marked thickening of the bone, which was extensively curetted. Microscopic examination, however, showed the disease to be periosteal sarcoma. The tumor grew rapidly after the operation.

When we first saw the patient in consultation in June, 1920, the lower two thirds of the fibula was occupied by a large tumor, apparently of periosteal origin, fungating in the central portion, at the site of the recent curetting; the glands in the groin were enlarged; one was the size of an English walnut. We advised immediate amputation to be followed by the use of the mixed toxins. Amputation was performed by Dr. Whitman, and the patient was then put on the toxins under my direction. Microscopic examination by Dr. F. M. Jeffries showed round cell sarcoma of periosteal origin. The tumor was classified by Dr. Ewing as endothelioma.

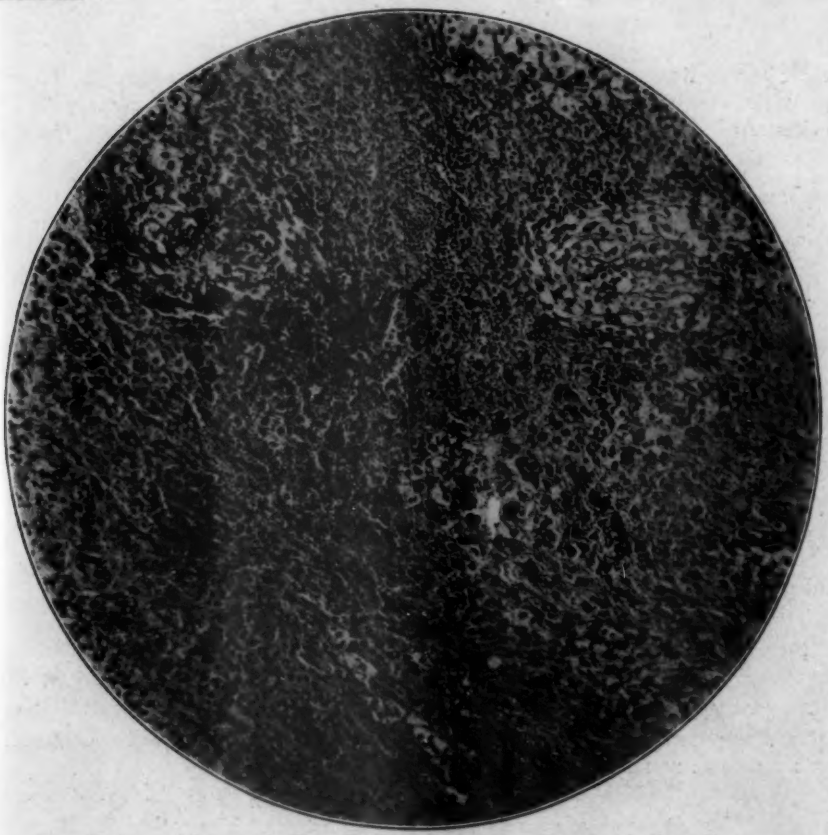

Fig. 47 (case 85 in table 7).—Periosteal round cell and spindle cell sarcoma of humerus; amputation; recurrence; incomplete removal; prolonged toxins; the patient was well eight years and then died of pulmonary metastases.

The toxins were given daily up to the point of obtaining a marked reaction; then three times a week. The glands in the groin decreased somewhat in size but did not disappear. In July a gland was removed for microscopic examination and pronounced round cell sarcoma. The toxins were kept up until the middle of August, when the patient was permitted to go home on account of the excessive heat. Reexamination, October 23, showed the inguinal glands to have increased in size, and a hard mass the size of a child's head was discovered in the right iliac fossa, evidently involving the retroperitoneal glands. A roentgenogram of the chest showed well developed, unquestionable metastases of the lung. The

patient was admitted to the Memorial Hospital, October 27, where he received 10,109 millicurie hours of radium at 7 cm. distance. The family was urged to leave the child in the hospital for further treatment, but as a hopeless prognosis had been given, they took the child home. No further toxins or radium treatments were given.

In the early part of May, 1921, we received a letter from the father of the child stating that the latter was apparently in perfect health and going to school regularly. He was brought to the Memorial Hospital, September 19, when a careful examination failed to reveal any evidence of a tumor in the abdomen or groin, and a roentgenogram of the chest showed no evidence of the metastasis that had been present in the preceding October. The patient was shown at a clinic at the Memorial Hospital to the members of the American College of Surgeons in October, 1924, at which time he was in excellent condition with no evidence of the disease in the groin or abdomen. A roentgenogram taken on the

Fig. 48 (case 96 in table 7).—Periosteal sarcoma of humerus. The patient refused amputation and was treated by toxins, roentgen ray and radium. Death occurred from metastases one year later.

same day showed the chest entirely free from metastases. The patient is still well at the present time, July, 1926, six years later.

CASE 23.—*Osteogenic sarcoma of the femur of central and periosteal involvement; round cell, probably endothelioma.*

D. M. S., a man, aged 22, was admitted to the Memorial Hospital, July 20, 1920, having been referred by Dr. Walton Lee of the Pennsylvania Hospital. In October, 1918, the patient sustained a fracture of the left leg; during 1919 he suffered from severe pain and swelling. In March, 1920, he was admitted to the Pennsylvania Hospital and was operated on by Dr. Walton Lee, April 17. The process was found to extend through the larger part of the shaft of the femur, and the larger portion of the bone was removed. The microscopic examination report (Pennsylvania Hospital), March 17, was osteogenic sarcoma of the femur.

Physical examination on admission to the Memorial Hospital, July 20, showed a thickening of the central portion of the shaft and middle portion of the left femur, with considerable enlargement. The clinical and roentgen-ray diagnosis

was sarcoma. While at the Memorial Hospital the patient was treated with massive doses of radium (60,804 millicurie hours at 7 cm. distance) and the mixed toxins; the latter were injected systemically in the buttocks. He received eleven doses while in the hospital, and further injections were given at home.

The patient was well when last heard from, February, 1926, six years later.

CASE 24.—*Periosteal osteogenic sarcoma of tibia.* J. C., a boy, aged 15 years, in the latter part of July, 1921, while playing was struck with a baseball on the

Fig. 49 (case 108 in table 7).—Inoperable sarcoma of first rib (clinical and roentgen-ray diagnosis).

inner aspect of the right tibia. Shortly after, a small lump appeared at the site of the injury and steadily increased in size; pain soon followed, and the patient walked with great difficulty. Wet dressings were at first applied, and later plaster strappings. Four electric treatments were given by Dr. Sidney Twinch of Newark, N. J., who had a roentgenogram taken and pronounced the trouble sarcoma. The patient was then referred to us for treatment. He was admitted to the Hospital for Ruptured and Crippled in the early part of October, 1921.

Physical examination at this time showed enlargement of the upper half of the right tibia, apparently of bony origin, extending up to but apparently not involving

the joint. There was slight restriction of motion at the joint but no effusion. The clinical diagnosis was periosteal sarcoma apparently of traumatic origin.

October 5, we performed an exploratory operation: a 3-inch (7.6 cm.) incision was made over the anterior portion of the right tibia just below the knee joint; the periosteum was found to be markedly thickened and intimately connected with the neoplasm, which apparently involved the greater portion of the cancellous tissue of the bone. The patient was immediately started on systemic injections of the mixed toxins of erysipelas and *Bacillus prodigiosus*. He was sent to the Memorial Hospital, October 21, where he received radium treatment in the form of a pack over various areas at 6 cm. distance, totaling 40,162 millicurie hours. Some definite decrease in the size of the tumor was noticed after the treatment. A

Fig. 50 (case 108 in table 7).—Eight years later; recovery under toxins and radium treatment.

roentgenogram taken in November showed the right tibia occupied by a periosteal osteogenic sarcoma involving the entire upper half, and apparently extending into the joint as well. There was some evidence of marked new bone production. This picture, when compared with one taken in October, showed some decrease in the size of the tumor. The toxins were kept up until twenty-eight injections had been given. The improvement, however, proved only temporary, and Dec. 2, 1925, an amputation at the midfemur was performed by one of us (B. L. C.); the wound healed by primary union. Following the amputation, the toxins were immediately resumed as a prophylactic, and continued at home for about six months by the local physician. A microscopic examination was made by Dr. F. M. Jeffries, who reported osteosarcoma; Dr. James Ewing's microscopic diagnosis was perios-

teal osteogenic sarcoma. The patient has remained well up to the present time, more than five years later. This case has been reported in the Bone Sarcoma Registry.

CASE 25.—*Sarcoma of tibia (clinical and roentgen-ray diagnosis), probably endothelioma; treated with toxin and radium; limb saved; patient well seven years later.*

Fig. 51 (case 117 in table 7).—Periosteal sarcoma of femur after prolonged roentgen-ray treatment; death from metastases.

W. P., a man, aged 55, was referred to us by Dr. Alfred M. Rowley of Hartford, Conn., in July, 1919. Four years before the patient had fallen from a ladder; four days later he suffered a fracture of the upper portion of the tibia; the leg was placed in a plaster cast for three weeks. Two years later, while getting off a street car, he fell, fracturing the same tibia. Roentgen-ray examination

showed extensive bone destruction of the middle and upper portion of the shaft, involving both central portion and periosteum. No exploratory operation was done at the Memorial Hospital; he was treated with radium locally and the toxins systemically for several months. The fracture reunited, new bone formed, and when last heard from, in July, 1926, six years later, the patient was still in excellent condition.

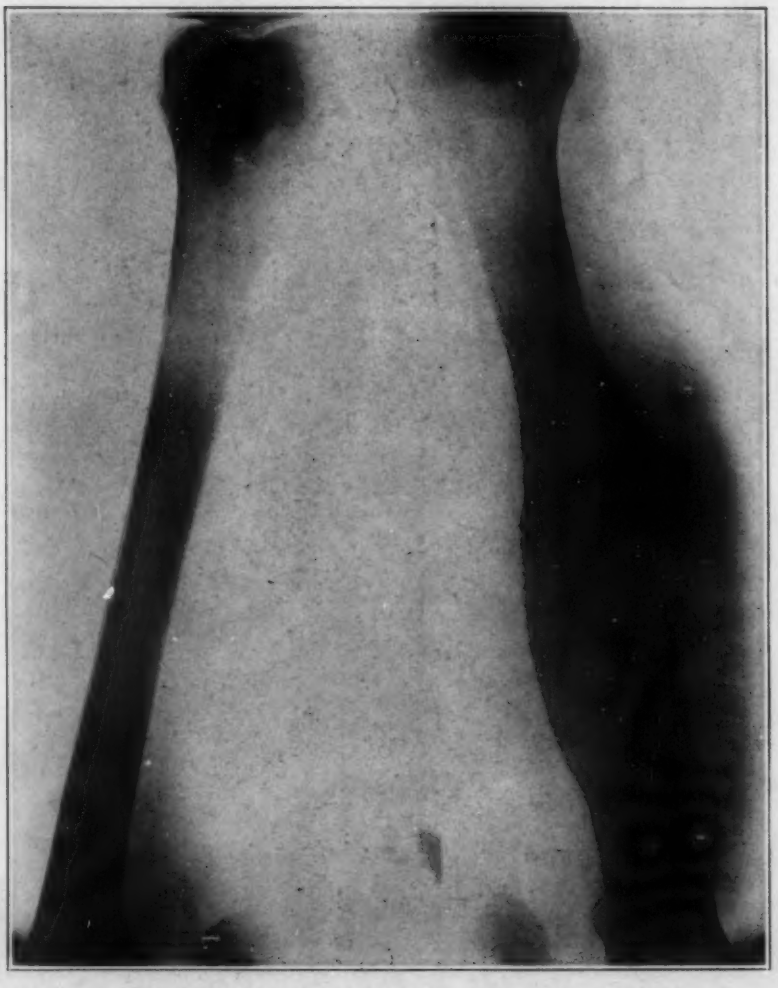

Fig. 52 (case 117 in table 7).—Periosteal sarcoma of femur.

CASE 26.—*Periosteal osteogenic sarcoma of femur.* H. S., a man, aged 19, was referred to us by Dr. H. Hallarman of New York, April 23, 1920. The family history was negative. Four months before the patient had fallen but did not recall distinctly that he had injured the right knee. One month later he noticed pain in the right popliteal space, which was treated with local applications on the assumption that it was of rheumatic origin. Two weeks later he noticed a

swelling on the outer aspect of the femur just below the knee joint; this steadily increased in size. The pain became very intense necessitating two treatments with small doses of radium before the patient was admitted to the hospital.

Physical examination at the time of his admission to the Hospital for Ruptured and Crippled showed enlargement of the lower end of the femur most marked in the region of the outer condyle, extending to the popliteal space and

Fig. 53 (case 121 in table 7).—Periosteal sarcoma of shaft of femur of unusual malignancy. Roentgen-ray treatment was given for six weeks; amputation was followed by metastases in four weeks.

upward for a distance of 3 inches (7.6 cm.). It was apparently of bony origin, firm in consistence but not of bony hardness. The leg could be flexed almost to a right angle. The pain had diminished somewhat since the radium treatment. The patient was put on systemic injections of the mixed toxins at once; these were continued three or four times a week. At the end of three weeks there was definite decrease in the size of the leg. The injections were continued regularly until

early July, when a slight increase in the size of the tumor was noticed. He was transferred to the Memorial Hospital, where the radium pack was applied, a total of 20,958 millicurie hours over two areas at 6 cm. distance.

He returned to the Hospital for Ruptured and Crippled and the toxins were resumed in doses up to 24 minims without marked reaction. While the tumor

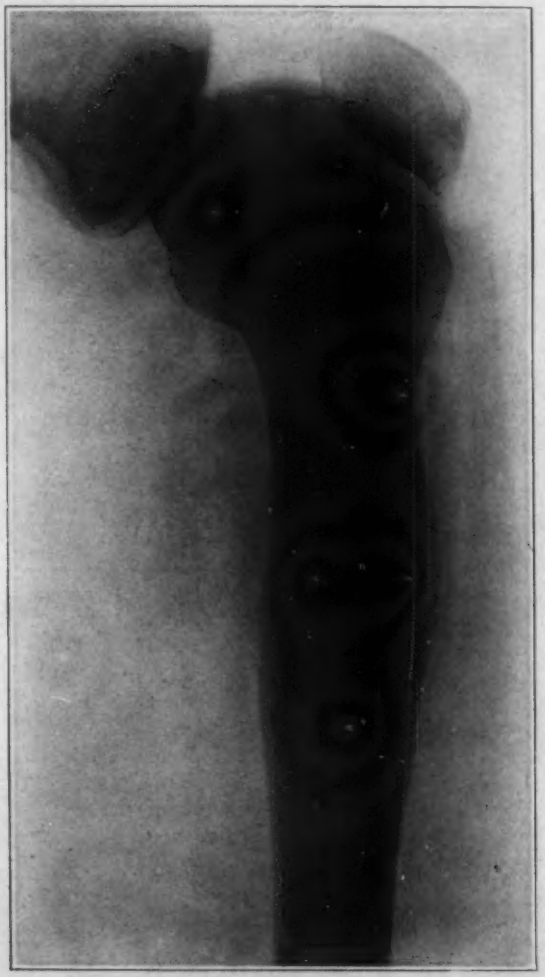

Fig. 54 (case 121 in table 7).—Periosteal sarcoma of shaft of femur.

showed some diminution in size, the improvement was only temporary, and it again began to increase. There was considerable synovitis, and the roentgen rays showed an extension of the disease higher up in the femur with an increase in thickness and greater destruction of the dense tissue of the bone itself. The patient finally consented to an amputation, which was performed by one of us, just below the trochanter, in August, 1920.

Microscopic examination was made by Dr. F. M. Jeffries, who reported periosteal neoplasm, apparently originating in the popliteal region and extending nearly

around the femur. Microscopic examination was made by Dr. James Ewing, who reported malignant spindle and giant cell osteogenic sarcoma; considerable production of osteoid tissue in the marrow regions; many areas of hemorrhage and some points of mucoid degeneration; some broad areas of hyaline material without cells. He stated that radium effects could be traced in the hemorrhages,

Fig. 55 (case 121 in table 7).—Two weeks later than figure 54.

mucoid degeneration, irregular calcification, and general hyperchromatosis of the tumor cell nuclei.

The patient made a good recovery and the toxins were resumed, and kept up with occasional intervals of rest for six months. He has remained in excellent condition up to present time, six years later. This case is registered by the Bone Sarcoma Registry.

CASE 27.—*Periosteal round cell sarcoma of tibia treated with toxins and radium; patient well five years later; limb saved.*

A. K., a boy, aged 16 years, with a negative family history, had a fall in May, 1920, while playing basketball. Two months later he felt pain in the left knee, which gradually increased in severity. Three casts were applied; the first was worn for eight weeks; the second for six weeks, and the third for about eight weeks, or until his admission to the Hospital for Ruptured and Crippled, Feb. 2, 1921. The day after he entered an exploratory operation was performed by Dr. Percy Roberts, who removed by curet a mass situated at the head of the tibia on the posterior aspect. The microscopic diagnosis of Dr. F. M. Jeffries was round cell osteosarcoma. The mixed toxins were begun February 10, and continued in gradually increasing doses up to 10 minims. Examination, March 10, showed the wound healed, and the knee joint movable so that it could be flexed to a right angle without pain or resistance; the patient's general condition was excellent. Roentgen-ray examination, April 14, showed no extension of the tumor process. April 18, he was transferred to the Memorial Hospital. On his admission, a roentgen-ray examination was made by Dr. Herendeen, who reported as follows: "Plate of chest is negative for metastases. In the internal condyle or tuberosity of the left tibia there is a large area of rarefaction, bone absorption or destruction; the process has not definitely broken through the cortex."

It was decided to supplement the toxins with radium, and from May 7, 1921, to November 29, the patient received over various aspects of the knee radium packs applied at 6 cm., a total of 96,554 millicurie hours.

The roentgen-ray report by Dr. R. E. Herendeen, July 28, 1922, was: "Plate of chest reveals evidence of an infiltration, probably tuberculous. Plate of tibia reveals evidence of further calcification and favorable progress."

The roentgen-ray report, June 28, 1924, was: "Plate of chest reveals no evidence of sarcoma metastases. Extensive pulmonary tuberculosis present. Evidence of some improvement in process in upper end of tibia."

Physical examination, June 25, 1924, showed the motion of the knee to be normal; the patient had been in a home for tuberculous patients for a year. Examination in May, 1925, showed the local condition to be normal, and the lung condition to be slightly improved. The lung condition soon become worse, and the patient's general condition rapidly declined; he died in November, 1925. The microscopic diagnosis of Ewing was osteogenic sarcoma. The case is registered by the Bone Sarcoma Registry.

CASE 28 (Dr. Douglas Quick).—*Periosteal sarcoma of humerus treated with radium for seven months; amputation; patient well more than three years later.*

L. O., a woman, aged 31, in November, 1920, noticed a small swelling on the right elbow; this slowly increased in size. In March, 1921, it began to increase more rapidly and was very painful; a biopsy was performed at this time by Dr. Charles A. Elsberg. The patient was admitted to the Memorial Hospital, Dr. Quick's service, April 21, at which time examination showed a large tumor just above the elbow 15 inches (37.5 cm.) in circumference. Roentgen-ray examination showed apparently no bony involvement, and an apparently intact periosteal line. The patient was treated by Dr. Quick with radium in the form of packs; from April to November, 1921, she received a total of 85,000 millicurie hours. The tumor steadily increased in size in spite of treatment and an amputation was performed by Dr. Quick, November 16. The microscopic diagnosis of Ewing was large spindle cell sarcoma, apparently of periosteal origin. This patient moved west within a year after amputation and only indirect information as to her condition has been received.

The patient received no prophylactic treatment of any kind; she was well when last traced, more than three years later.

CASE 29.—*Periosteal sarcoma of humerus, with pulmonary metastases; clinical and roentgen-ray diagnosis; recovery under toxin treatment alone; well eight years.*

B., a man, aged 24, while riding on an engine, lost his balance and fell, striking the running board and receiving a severe strain of his shoulder. Shortly afterward he felt pain, and later a swelling developed in the upper end of the humerus; this grew rapidly, involving the whole upper end; the veins were markedly dilated. A spontaneous fracture occurred shortly afterward. Roentgen-ray examination showed a metastatic growth of the lung.

Fig. 56 (case 122 in table 7).—Central sarcoma of femur; clinical and roentgen-ray diagnosis: benign giant cell tumor; no improvement under prolonged radiation; proved a malignant central sarcoma. The patient died one year later.

An exploratory operation was performed by Dr. L. D. Mackid of Calgary, Canada, in February, 1918, at which time a large amount of gelatinous sarcoma-like material was evacuated; the condition was regarded as hopeless from a surgical point of view. In March, 1918, Dr. Mackid began the use of the mixed toxins, pushing the dose to the point of producing a severe reaction. At the end of two months the disease was apparently under complete control; there was no further increase in the size of the tumor and it gradually grew smaller. The toxin treatment was kept up until July, when he was given a rest of three months, after which the injections were resumed by our advice. The spontaneous fracture reunited, the patient gradually regained complete use of his arm, and his general health returned to normal. He was still in excellent condition, and working on a farm, seven years later. Roentgenograms were taken before and after treatment. The patient was well in July, 1926, eight years later.

CASE 30.—*Osteochondrosarcoma of humerus.* E. J. D., a man, aged 27, with a negative family history, had always been in good health until September, 1917, when, preparatory to entering the army, he was given a series of vaccinations in the muscles of the upper part of the right arm. A few weeks later he complained of soreness at the site of the inoculations, also of loss of function of the arm; a swelling appeared and slowly increased in size. In January, 1919, he was operated on by Dr. James M. Hitzrot at the New York Hospital; a portion of the humerus was resected and grafts from the tibia were implanted.

The microscopic report of Dr. W. G. Elser, pathologist to the New York Hospital, was: "Osteochondrosarcoma; diffuse, infiltrating growth involving the entire bone, extending into the surrounding muscle and fascia; extensive infiltration of muscle tissue. Diagnosis: osteogenic sarcoma." This diagnosis was later confirmed by Ewing. February 28, the patient was referred to us for radium treatment. Physical examination on admission to the Memorial Hospital at this time showed that the wound had healed and there was no evidence of the tumor remaining.

From Feb. 28, 1919, to May 16, 1921, he received 82,417 millicurie hours of radium in the form of a pack at 6 cm. distance. Frequent roentgen-ray examinations were made by Dr. Douglas Quick, who reported as follows: April 12, destructive process advancing in the upper end of resected humerus; May 9, 1919, malignant process in humerus steadily advancing; June 3, 1919, some attempt at callus formation about point of junction with the bone graft; it is very doubtful if there is any advance in the malignant process; June 28, 1919, considerable callous formation but no suggestion of new growth.

A curettage was done by one of us, July 21, 1919, and the specimen was submitted to Ewing for microscopic examination, who reported, "No definite tumor tissue but many dark staining round cells."

The patient was discharged from the Memorial Hospital on Nov. 29, 1919, at which time there was no evidence of a return of the tumor. A recent note from him states that he is still well, more than six years after treatment. This case was reported in the Bone Sarcoma Registry.

CASE 31.—*Periosteal sarcoma of femur; hip joint amputation followed by toxin treatment; patient well three years later.*

H. P., a man, aged 27, with a negative family history, in October, 1912, received an injury to the upper part of the left femur; two or three weeks later he began to have pain in this region, but noticed no enlargement until January, 1912, when he observed a fusiform swelling in the upper part of the femur. This rapidly increased in size, and was accompanied by marked deterioration in general health. The patient was referred to us by Dr. William L. Bradley of New York City,

March 28, 1912. He had been confined to his bed for two or three weeks, suffering severe pain. Physical examination at that time showed a markedly emaciated and cachectic man. Examination of the left femur showed a fusiform enlargement occupying the whole upper half of the thigh, the largest circumference measuring 22 inches (55.5 cm.). The tumor extended well beyond Poupart's ligament anteriorly, and posteriorly above the trochanter. The joint apparently

Fig. 57 (case 122 in table 7).—Three weeks later than figure 56.

was not involved, and there were no glands in the groin. The skin was not adherent, but was of a purplish color, due to a large amount of dilated veins. There was no evidence of metastasis. The patient was admitted to the Memorial Hospital, March 31, 1912; on the day following a hip joint amputation was performed by one of us (W. B. C.); the growth extended so high up that after the leg was removed the muscular tissues retracted underneath. Although there was little hemorrhage, the patient's general condition was extremely bad, and

when the operation was completed he was practically pulseless. He was given 4 ounces (118.4 cc.) of black coffee and whisky by rectum, and on reaching the ward, 1,000 cm. of salt solution intravenously. He rallied shortly afterward and was in good condition on the following morning.

The microscopic report of Ewing was: "The myxochondrosarcoma with the cartilage is almost completely degenerated into mucous tissue; there is some well defined embryonal cartilage."

The mixed toxins were begun as soon as the patient had recovered from the operation, and were continued for three months. His general condition improved steadily; he was shown before the Clinical Congress of Surgeons of North America in November, 1912, at which time he was in excellent condition without any trace of a recurrence; he had gained 30 pounds (13.6 Kg.) in weight. At the time of my last examination, three years later, he was still in perfect health.

CASE 32 (Dr. George B. Packard, Jr., Denver).—*Sarcoma of upper third of femur; inoperable (clinical and roentgen-ray diagnosis); recovery under toxins; patient well five years later; probably endothelioma.*

G. M., a boy, aged 9 years, in the latter part of 1919 fell on a hard floor, shortly after which a swelling developed in the upper third of the left femur and grew rapidly; this was accompanied by a great deal of pain and considerable loss of flesh and strength. A roentgenogram taken at the time of the injury showed no pathologic lesion. The patient came under the care of Dr. G. B. Packard four months later. Roentgen-ray examination by Dr. Brandenburg, Jan. 2, 1920, showed general bone destruction involving the head, neck and trochanter of the femur with a complete pathologic fracture of the neck close to the head. The diagnosis was osteosarcoma. Dr. Packard stated that the patient's condition was too poor to warrant even an exploratory operation; he had been bedridden for three months, was markedly emaciated, and had two huge sloughing ulcers on his back.

January 6, he was placed on the mixed toxins of erysipelas and *Bacillus prodigiosus,* beginning with a dose of 0.01 cc., increasing gradually to 0.8 cc. (the highest dose). He received almost daily injections, 119 in all being given up to October 23; the highest reaction obtained was 104 F. The patient showed almost immediate and steady improvement. By March 1 the pain had entirely ceased, he had a good appetite, had gained considerable weight, and was up and about in a wheel chair. There was no great change in the size of the tumor, but the edema and prominent veins had disappeared and the bed sores were healed. By April 25, the general appearance of the patient was excellent; he had no pain, and the tumor had decreased somewhat in size. By June 15 he was able to walk with crutches. By August 15 he was still unable to lift the extended leg in bed (probably a nonunion following tumor absorption). Roentgen-ray examination, September 2, showed: "The sarcoma has involved the upper end of the femur, the trochanters, the neck and head of the femur, and slightly the acetabulum, with almost complete destruction of the head and neck and considerable destruction of the trochanters. There is no evidence of union. There is good healing and the beginning of an attempt at repair." The new bone formation apparently continued; there was complete restoration of function, the pathologic fracture reunited, and the patient was in excellent condition in November, 1925, with no evidence of a recurrence, five years later.

We have been in close touch with Dr. Packard in the treatment of this patient, and he has given me the roentgenogram taken immediately after the injury as well as other pictures taken after the tumor had developed. While no microscopic examination was made in this case, we believe that the clinical history and

the roentgenograms leave no reasonable doubt that the condition was a sarcoma, probably of the endothelioma type.

CASE 33.—*Fibroperiosteal sarcoma of femur.* B. M., a woman, aged 33, first felt pain in the right knee in March, 1918; six months later a swelling appeared and slowly increased in size. An exploratory operation was performed by

Fig. 58 (case 133 in table 7).—Periosteal sarcoma of femur.

Dr. George Woolsey at Peekskill Hospital, Jan. 25, 1919. The microscopic diagnosis was fibrosarcoma. The patient was admitted to Memorial Hospital, in the service of Dr. H. H. Janeway, March 13.

Physical examination at this time showed a swelling, the size of a small orange, in the lower extremity of the right femur. The clinical diagnosis was sarcoma of the femur. March 13, the patient received a radium treatment in the form of a pack, 14,804 millicurie hours at 6 cm. distance; in addition, she received

five roentgen-ray treatments from May 23 to September 22. The disease was under almost complete control for a period of more than three years. At the end of this time, there was evidence of recrudescence accompanied by bone destruction and a pathologic fracture occurred. The leg became useless and was amputated by Dr. Woolsey, March 27, 1924. The microscopic diagnosis of Ewing was long spindle cell fibrosarcoma with occasional points of hyaline osteoid tissue. She was reported well in August, 1926, two and one-half years after amputation.

CASE 34.—*Tumor of the left tibia, endothelioma (?); roentgen-ray radiation; recovery; well two and one-half years later.*

S. L., a woman, aged 19, fell downstairs in February, 1922, striking the left leg just below the knee; two months later she felt a sharp pain radiating from the knee to the thigh and hip. She was admitted to the Hospital for Ruptured and Crippled in the early part of September, and was treated with local applications without relief. The left leg became greatly swollen, and walking became very difficult; her temperature rose to 101-102. Dr. Percy Roberts made a diagnosis of osteomyelitis and advised operation. This diagnosis was confirmed by roentgen-ray findings. The patient was referred to the outpatient department of the Memorial Hospital, September 26. Physical examination on admission showed a diffuse swelling over the anterior aspect of the left tibia just below the head. The circumference of the left calf at that point measured 11 inches (27.9 cm.); the opposite calf measured 10¾ inches (27.2 cm.). The swelling covered an area from about 5 to 6 cm. wide; it was slightly elevated and somewhat tender on pressure.

Roentgen-ray examination by Dr. R. E. Herendeen, September 29, stated: "The plate of the tibia reveals evidence of changes in the upper third; it has some of the features seen in an endothelioma. It lacks the appearance usually noted in periosteal growths or giant cell tumors. The diagnosis is endothelioma. The plate of the lungs does not reveal definite evidence of metastases."

The patient received six roentgen-ray treatments from September 26 to December 29. Roentgen-ray examination, Nov. 7, 1923, showed marked improvement in the condition of the tibia, with no evidence of a recurrence; the patient's general health was excellent.

In the absence of a microscopic examination in this case and the fact that there were several features pointing to osteomyelitis, it cannot be regarded definitely as a malignant tumor. Our diagnosis at the time treatment was begun was osteitis.

CASE 35.—*Osteogenic sarcoma of femur.* I. L., a man, aged 20, was admitted to the Hospital for Ruptured and Crippled, March 13, 1925. In March, 1921, four years before, the patient's left leg was caught in the door of a subway train and was severely squeezed. Three days later he felt some pain, which became more severe and localized over the greater trochanter; the pain was of an intermittent nature, and kept the patient in bed only a few days at a time; however, the attacks became more frequent. He was admitted to the Jewish Hospital of Brooklyn, July 25, 1923, where an operation (osteotomy and curetting of bone) was performed, August 7. The microscopic diagnosis was osteomyelitis. Roentgenograms taken at this time showed nothing at all suggestive of sarcoma, only a marked thickening of the femur with sclerosing of the bone, typical of a chronic sclerosing osteitis.

A roentgenogram taken at the time of the patient's admission to the Hospital for Ruptured and Crippled showed that certain changes had taken place since the

last picture of two years before; the bone was larger and thicker and the density seemed not quite so marked; instead of the periosteal line of the bone being intact, there were a few erosions in one area—a few indentations in the normal outline. Apparently, there was a small amount of new bone production beyond the normal line. The picture did not permit one to make a diagnosis of sarcoma, although it was more suggestive of sarcoma than the earlier pictures.

Fig. 59 (case 133 in table 7).—After two months' treatment with high voltage roentgen rays. The patient died a few months later of lung metastases.

An exploratory operation was performed, March 16, 1925. When the muscle was cut through, some soft, vascular tissue was found which had broken through the periosteum. There was some discussion at the time as to whether this was tumor tissue or the product of an old inflammatory process; some of it was taken for culture and section. The periosteum around the bone was thickened and a section of this also was taken for examination. The microscopic diagnosis of

Dr. F. M. Jeffries was mixed cell sarcoma; that of Dr. James Ewing, osteogenic, polygonal cell, malignant sarcoma.

The patient was put on the mixed toxins, April 1, and the dose daily increased up to the point of producing a marked reaction. Immediate improvement was noticed. The pain disappeared, the tumor steadly diminished in size, and examination in the early part of July, 1925, showed him in excellent local and general condition. He has gained 17 pounds (7.7 Kg.) in weight, and is able to walk about with an apparently normal leg. The improvement in his local condition was further confirmed by recent roentgenograms. The patient was still well when examined in July, 1926.

CASE 36.—*Periosteal round cell sarcoma of clavicle; total excision followed by toxin treatment; patient well fifteen and one-half years later; probably endothelioma.*

J. V., a boy, aged 16 years, with a negative family history, in the beginning of October, 1909, while going down stairs, tripped and in trying to save himself caught hold of the banister with his left hand, bringing himself to a sudden stop with a severe jerk. This caused a good deal of strain on the left shoulder and clavicle. Shortly after this he was riding a motorcycle, which broke down; he was obliged to tow it for a distance of ten miles, using his left hand almost entirely to do the towing. In the end of October, he first felt pain and soreness in the region of the left clavicle, and one week later a swelling was noticed at this site. November 20, he consulted Dr. Alfred Potter of Brooklyn, who found a fusiform enlargement of two thirds of the inner portion of the shaft of the left clavicle. Roentgenograms were taken which showed a typical periosteal sarcoma; the outline of the periosteum was nearly lost.

The patient was referred to us, and from the clinical and roentgen-ray evidence, we made a positive diagnosis of periosteal sarcoma, and urged an immediate removal. At this time the tumor was about the size of an English walnut, there were no enlarged glands, little pain, and he was in excellent general condition. November 22, with the assistance of Dr. William A. Downes, we performed a total excision of the clavicle as follows: An incision was made over the outer surface of the clavicle over its entire length. After we had separated the periosteum and the bone, a Gigli's wire saw was passed beneath the clavicle 1½ inches (3.7 cm.) from the outer extremity, well beyond the tumor. The inner and larger portion was then lifted up and dissected from the subclavian muscle and separated from its attachments until the sternocostal articulation was reached; disarticulation was then accomplished with little difficulty and no hemorrhage. The outer portion of the clavicle was removed with a Rongeur forceps. The microscopic diagnosis of Dr. James Ewing was periosteal round cell sarcoma (myeloma).

The patient made an uninterrupted recovery, the wound healing by primary union. Before his discharge from the hospital on the tenth postoperative day, the mixed toxins were begun; these were later given at home for a period of three months by his family physician. Almost no deformity resulted from the operation and the patient retained complete functional use of his arm. He served in the army in France during the war. At the present time, fifteen and one-half years later, he is in excellent condition with no evidence of a recurrence. We believe this case to have been one of endothelial myeloma. There were no giant cells and the tumor was laminated without new bone production.

CASE 37.—*Periosteal sarcoma, small, round cell, of left clavicle; total excision followed by toxin treatment; patient well seventeen years later.*

J. W. H., a man, aged 34, gave as his family history that his father died of cancer of the stomach; there was no tuberculosis in the family. In January, 1908, the patient was struck on the left clavicle and almost knocked down by a plank; shortly after a local swelling appeared and grew rapidly; this was accompanied

Fig. 60 (case 141 in table 7).—Periosteal sarcoma of upper end of humerus.

by mild pain. March 23, he consulted Dr. W. L. Hunt of Bangor, Maine, who made a diagnosis of sarcoma; this was confirmed by Dr. S. W. Johnston of Belfast, Maine, who then referred the patient to Dr. Maurice H. Richardson of Boston. The latter did a total excision, May 18; the tumor occupied the middle and inner third, and the operation was most difficult. A microscopic examination was made by Dr. W. F. Whitney of the Massachusetts General Hospital, who pronounced it a small, round cell sarcoma. The patient was then referred to us for prophylactic toxin treatment. At this time there was considerable infiltration in the

whole lower cervical region, suggesting either a recurrence or incomplete removal; this gradually cleared up under the toxins and entirely disappeared at the end of two months. The injections were resumed at home and carried out under my direction by the family physician, Dr. H. L. Trulock of Dismount, Maine. Dr. Richardson believed the prognosis so grave from operation alone that he stated that if this man made a permanent recovery entire credit was to be given to the toxin treatment. We examined the patient in February, 1909, and found him in excellent health, having gained 26 pounds (11.8 Kg.) in weight. He has remained well up to the present time, seventeen years later. This case would probably now be classed as endothelioma by Ewing.

CASE 38.[23]—*Periosteal round cell sarcoma of lower third of femur. Recovery under toxins alone; limb saved; patient well seventeen years.*

A man, aged 58, had a negative family history. An exploratory operation was performed by Dr. G. M. Williamson, March 6, 1909, for a rapidly growing tumor of about two months' duration. The microscopic diagnosis report of Dr. Ruediger, the director of the state university, was round cell sarcoma. An immediate amputation was advised by several surgeons.

March 18, the patient was referred to Dr. William J. Mayo, who confirmed the diagnosis and refused to amputate, believing the condition to be inoperable. In writing to Dr. Williamson, the Drs. Mayo stated: "There is a question in our minds that we could accomplish anything by amputation." On Dr. Mayo's recommendation, the patient was put on a course of the mixed toxins of erysipelas and *Bacillus prodigiosus*. The injections were given by Dr. Williamson under our direction; they were continued for about four months, the dose being increased to the point of producing a marked reaction. The patient made a complete recovery; he is in excellent health, with a useful limb, over sixteen years later.

We have been unable to obtain a section of the original tumor, and the slide of the state laboratory was lost. On writing to the Mayo Clinic for further data on the case, the following report was received by Dr. Henry W. Meyerding, March 6, 1925: "The radiologist here reported some roughening of periosteum; the shaft of the bone appeared normal, and there was a shadow of soft tissue which might possibly be sarcoma. Dr. E. H. Beckman operated, March 22, 1909. He described his operation as a curettage of necrotic tissue and removal of a scale of bone. The specimen sent to the laboratory was reported 'inflammatory—possibly lues' by Dr. W. C. McCarty. This diagnosis has recently been confirmed by Dr. Broders."

As the curettings of an unhealed sinus from an exploratory operation are not infrequently negative, we believe that the clinical and roentgen-ray diagnosis supplemented by the positive microscopic diagnosis of the state laboratory, leaves little question of the correctness of the original diagnosis of periosteal round cell sarcoma. This was probably a case belonging to Ewing's endothelial myeloma group. There was no question in the minds of the Mayos that it was sarcoma.

CASE 39.—*Sarcoma of humerus; toxin treatment; apparent disappearance followed by recurrence; amputation followed by toxins; recurrence; incomplete removal of growth, followed by further toxin treatment; patient well ten years and then died of lung metastases.*

F. L., a man, aged 35, with a negative family history, was referred to us by Dr. J. M. T. Finney of Baltimore, in June, 1910. At this time he had the

23. This patient was treated by Dr. G. M. Williamson of Grand Forks, N. D., under our direction; a full report was published in Tr. North Dakota S. M. A., 1910.

appearance of a man of splendid physique; he was 6 feet tall and weighed 180 pounds (81.6 Kg.). Early in January, 1910, he had fallen and received a spiral fracture of the left humerus at about the junction of the middle and upper thirds. He was treated at the Hudson Street Hospital, and then returned to Baltimore, where he was treated by Dr. W. A. Fisher. A roentgenogram taken at this time

Fig. 61 (case 141 in table 7).—Three months later than figure 60.

showed a spiral fracture without any trace of a new growth. Three weeks later, he felt severe pain at the site of the fracture. Another roentgenogram was taken which showed that in the meantime a well marked tumor had developed, apparently a sarcoma, involving both the central portion and the periosteum. The growth increased rapidly in size, and was accompanied by severe and constant pain. An exploratory operation was performed by Dr. Finney in June, revealing a large sarcomatous growth that involved both the central and the periosteal

portions of the humerus and extended from about the junction of the middle and upper thirds nearly to the head of the bone; the bone was completely destroyed; a pathologic fracture had occurred, and there was a flail joint. The central portion of the tumor was curetted; in Dr. Finney's opinion, amputation offered no hope of a cure. June 15, the patient came to us and was immediately put on the mixed toxins; these were continued in small doses systemically in the pectoral region and a few in the arm.

The specimen was examined microscopically by Dr. James Ewing and pronounced a spindle cell osteogenic sarcoma; this diagnosis was confirmed by Dr. Joseph C. Bloodgood. There were no giant cells.

Under the toxins the tumor slowly and steadily decreased in size; there was immediate cessation of the pain which had been constant from the first appearance of the tumor; the shell of bone about the tumor, which had undergone spontaneous fracture, gradually became harder with the formation of new bone, and within a few weeks complete union had occurred; the large cavity gradually filled up with granulations. Several curettements showed the material to be sarcoma of the same type as the original tumor. Another roentgen-ray examination in the latter part of 1910 showed that the new growth had apparently entirely disappeared and there was firm union of the arm. The patient's general condition was excellent.

In November the granulations began to increase again in size and in spite of curettage, quickly recurred. A roentgenogram taken in December showed a small shadow starting in the periosteum, in the axillary region. In the early part of January, we performed a shoulder joint amputation. The patient remained well for about one year, and then developed a large, recurrent tumor, the size of two fists, in the pectoral region. We did an incomplete removal and put him on a prolonged course of toxin treatment. He remained in apparently good condition until April, 1912, when he complained of pain, and a mass below the clavicle at the top of our last incision. He consulted Dr. W. A. Fisher of Baltimore, who found a mass about 3 cm. in diameter and very sensitive. As it was impossible for the patient to return to New York at that time, he was sent to a local hospital, where Dr. Fisher, believing the present trouble to be a recurrence, removed the shoulder girdle; it proved, however, to be a large neuroma. The patient was more comfortable after the operation and gained steadily in weight and strength; in October, 1913, he weighed 212 pounds (96.1 Kg.), and was the picture of health. He remained well until 1920, when lung metastases developed; he died shortly after.

CASE 40.—*Large, osteogenic sarcoma of humerus, treated with toxins and radium; complete disappearance of tumor; patient well two years later.*

E. M., a man, aged 47, was referred to us by Drs. William C. Sheehan and John B. Deaver of Philadelphia, July 24, 1924. About a year and a half before the patient had tripped over a low fence and fractured the left humerus at the upper third. One year later a tumor developed at the site of the injury. Physical examination at the time of our first observation showed the left shoulder markedly swollen on the outer and anterior aspect, the swelling occupying the whole region of the deltoid, and extening up to the tip of the clavicle; it was soft in consistency, semifluctuating, and extended out to the pectoral muscle. The measurement over the axilla and tip of the clavicle was 21 inches (53.3 cm.), while the circumference at the highest point of the axilla was 15 inches (37.5 cm.). Motion at the shoulder was considerably limited; he could raise his left hand as high as his chin but not to the top of his head; abduction was about 45 degrees; the skin was normal in appearance; the veins were not dilated.

The roentgen-ray and clinical evidence was so clear that it was possible to make a definite diagnosis without a biopsy. Some of the surgeons who saw him believed the condition to be inoperable, so we decided that it was wise to try conservative treatment. He was immediately put on the mixed toxins, supplemented by a massive dose of radium (10,000 millicurie hours) at 7 cm. distance over three different areas. The tumor diminished 5 inches (12.7 cm.) in circumference in the short period of about four weeks, and the patient regained his lost weight. He proved extremely susceptible to the toxins, a very small dose producing a temperature of 104.5 F. In December, 1924, there was evidence of some slight increase in the swelling of the arm, and another radium pack was applied. The toxins were continued once a week until April, 1926.

Fig. 62 (case 141 in table 7).—Periosteal osteochondrosarcoma of humerus following prolonged roentgen-ray treatment. Amputation was performed, but no toxins were given. The patient died a year later of metastases in the lungs.

Physical examination in April, 1926, failed to show any evidence of enlargement; the patient's general condition was entirely normal, and he was performing his regular work daily. He is still well, July 30, 1926, two years since beginning treatment. He was able to resume work within two months after beginning of treatment. This case is registered in the Bone Sarcoma Registry as endothelioma. It should be noted that in this case the toxins were given directly into the tumor during the early treatment. A roentgenogram taken, Nov. 23, 1926, shows the function normal and no evidence of disease.

CASE 41.—*Recurrent osteogenic sarcoma of humerus; unsuccessful roentgen-ray treatment; removal of tumor followed by amputation; patient died from lung metastases eighteen months later.*

O. B., a man, aged 40, in April, 1923, began to experience severe neuralgic pain in the region of the head of the right humerus; hot applications were applied without relief. One month later, he noticed a diffused swelling at the site of the pain area. In July, 1923, he was operated on at the Union Hospital but no microscopic examination was made. One month later a recurrence was noticed. Physical examination at the time of his admission to the Memorial Hospital showed a recent scar over the anterior aspect of the right shoulder. At each end of the scar was a fungating small mound of vascular tissue with slight serous oozing and crusting. Beneath the scar was a firm discoid mass, apparently lying on the surface of the head of the humerus and more or less adherent to it; there was no adenopathy. The provisional diagnosis was recurrent sarcoma of the head of the humerus.

The roentgen-ray report of Dr. Herendeen, October 12, read: "Stereoscopic films of the shoulder reveal evidence of a destructive process involving the cortex of the anterior surface of the head and neck of the right humerus. The medullary portion of the bone is involved and only a slight amount of bone production is seen. The films lack the features of the usual type of periosteal osteogenic sarcoma or giant cell or central tumor. The appearance suggests a tumor having some of the properties of a chondrosarcoma, with its origin in the greater tuberosity or at the junction of the head with the shaft, and destroying the cortex and involving the medullary cavity with invasion of the soft parts beyond the cortex. The film of the chest does not reveal evidence of metastases to the lungs."

The patient was treated with high voltage roentgen rays from the time of his admission until Jan. 9, 1924. The tumor increased rapidly in size during roentgen-ray treatment. In February, 1924, he was turned over to us for amputation. At this time, physical examination showed the wound badly infected; the tumor had extended beyond the pectoral muscle; the patient's hemoglobin was low; while there was no evidence of lung metastasis, his general condition, and the extent of the tumor led us to regard the condition as inoperable. March 1, a large fungating tumor was removed by Dr. W. S. Stone, who used cautery and knife; the base of the tumor was treated with paste. The microscopic report of Dr. James Ewing was: "There is large spindle and giant cell sarcoma tissue, much inflamed and edematous, covered with diphtheric membrane. The tissue is too much altered to offer an opinion as to the neurogenic origin. No definite osteochondrosarcoma can be made out."

April 24, 1924, Dr. Frank Adair operated, removing the right arm together with a portion of the scapula and clavicle. Following the operation, it was necessary to give the patient a blood transfusion. The microscopic report of Dr. James Ewing then was: "Sections show a large spindle and giant cell sarcoma. The cytoplasm of spindle and giant cells is quite acidophil. The giant cells are of myeloid type, but with multiple multilobed nuclei. There is intertwining of fiber bundles. It is impossible to decide whether this is a periosteal osteogenic sarcoma or a myogenic sarcoma invading the bone; it is probably osteogenic."

Sept. 11, 1925, the patient was visited by the social service worker who reported him to be in very bad condition. The pulse was 132; he had difficulty in breathing, and he refused nourishment. Examination by his local physician revealed involvement of the mediastinum and both lungs; the cough was very profuse. The patient died in the latter part of September, 1925.

CASE 42.—*Endothelioma of tibia; partial control of disease under radiation; later evidence of further progress; amputation; patient well one and one-half years later. (Patient of Dr. James Ewing.)*

A. V., a boy, aged 17 years, had a negative family history and had suffered no trauma. During the year 1919, he felt intermittent aches and pains, which became more intense and were followed a couple of months later by a swelling of the tibia in the region of the upper third; there was no ulceration or redness. In November, 1920, an exploratory operation was performed for supposed osteomyelitis. The patient was admitted to the Memorial Hospital, Dec. 8, 1920. The roentgen-ray report of Dr. R. E. Herendeen stated: "Evidence of considerable proliferation in the periosteum of the upper end of the tibia is observed. There is no evidence of active bone destruction present. The medullary canal here is somewhat expanded."

Fig. 63 (case 142 in table 7).—Telangiectasia of humerus; treated with roentgen rays; amputation; no toxins; patient well two years later.

The microscopic report of Dr. Ewing on sections from the exploratory operation in November, 1920, stated: "This is a diffuse cellular tumor composed of small polyhedral cells without stroma. The cells show clear cell bodies, but material is crushed except in one portion. On this the diagnosis of diffuse endothelioma is based."

The patient was treated with radium in the form of a pack applied at 6 cm. distance; from Dec. 9, 1920, to May 16, 1923, he received a total of 91,191 millicurie hours. Definite improvement in the local condition followed radiation. Nov. 8, 1923, a biopsy was performed by Drs. W. S. Stone and Douglas Quick. The microscopic report by Ewing was endothelioma, with perithelial growth in dense scar tissue.

In November, 1923, the growth showed evidence of renewed activity; the patient complained of increasing pain and the roentgen rays showed probable

lowing the operation, and a smaller one the next night; his pain seemed somewhat improved.

The patient was readmitted to the hospital, June 20. At this time he complained of a great deal of pain; there was a marked swelling about the incision, which was semifluctuant but not tender. There was a hard gland in the inguinal region about three-fourths by one-half inch (1.8 by 1.2 cm.). His general appearance was cachectic.

Roentgen-ray examination, July 11, showed that proliferative bony change had taken place. There also was a very definite lifting and proliferation of the periosteum, particularly from the portion of the femur below the site of the disease. July 17, the patient was seen in consultation by one of us (W. B. C.) and a diagnosis of sarcoma was made. An immediate amputation was advised, but to this the patient would not consent. July 21, an exploratory operation was performed by one of us (B. L. C.), which revealed a soft tumor that communicated with the anterior bone; this was curetted under local anesthesia and submitted to Dr. Jeffries for microscopic examination; he reported sarcoma. The microscopic report of Ewing was malignant tumor of the bone marrow, probably endothelial myeloma.

A pathologic fracture later occurred. In view of the large size and rapid growth of the tumor, an immediate amputation was again urged, and performed by one of us (B. L. C.), July 31. Prophylactic toxins were given after operation and the patient is well, July 30, 1926, one year later.

CASES OF CENTRAL MALIGNANT SARCOMA

CASE 44.—*Periosteal sarcoma of tibia with metastases in lung; metastases controlled by roentgen-ray treatment alone for nearly two years; patient in hopeless condition in April, 1926.*

S. F., a woman, aged 41, was admitted to the Memorial Hospital in July, 1922. At the age of 14, or twenty-seven years before, the patient noticed a slightly diffused swelling of the right tibia accompanied by pain so severe as to cause her to limp. Three years later an operation was performed at St. Catherine's Hospital, Brooklyn (no microscopic examination). There was no sign of a recurrence until about five years before admission, or twenty years after the operation, when a persistent, sharp pain was felt at the site of the primary growth, followed shortly after by a swelling of the tibia, which steadily increased in size. In April, 1922, a second operation was performed by Dr. E. A. Parker.

The microscopic report was alveolar sarcoma, with the periosteum involved. This diagnosis was confirmed by Ewing, who pronounced it an osteogenic sarcoma. According to Dr. Parker, the roentgen rays showed roughening of the periosteum. On operating, he found a large, soft, very vascular mass; the periosteum was roughened. July 19, he made another incision, finding no pus, and he regarded the mass then present to be a recurrence.

Roentgen-ray treatment was given at the Memorial Hospital from July 24, 1922, to Jan. 5, 1923, nine exposures. February 6, Dr. R. E. Herendeen reported that the roentgen rays revealed evidence of sarcoma metastases in the lung, and that there was evidence of more production of bone seen in the plates of the head of the tibia.

April 9, 1926, the patient had had a marked recrudescence of the metastatic tumors and was going down hill rapidly.

CASE 45.—*Sarcoma of tibia, central, malignant, osteogenic; exploratory operation followed by prolonged toxin treatment; limb saved; patient well four years later.*

A. L., a woman, aged 22, was referred to us by Dr. Howard Lilienthal of New York in June, 1922. The patient had consulted Dr. Lilienthal in March, 1922, at which time she had a swelling of the left tibia just above the ankle;

Fig. 65 (case 155 in table 7).—Two years later than figure 64.

there was no pain and only slight lameness; there was no history of trauma. Roentgen-ray examination showed a tumor of central origin with considerable expansion of the lower end of the tibia; the bony shell apparently was not broken through. From the roentgenogram it was believed to be a giant cell tumor.

An exploratory operation was performed by Dr. Lilienthal in March, 1922, revealing a central tumor, about 3 inches (7.6 cm.) in length, with marked expansion of the bone. After curettage a transplant of fat was inserted in the cavity,

and the wound was closed. Shortly after the operation, the mixed toxins were begun by Dr. Lilienthal and the treatment was later carried out by Dr. I. Nadel under our direction.

We examined the patient, June 23, and found her in excellent condition. It was necessary for her to go west shortly after and the toxin treatment was resumed by Dr. Stanley Stillman of San Francisco, and kept up for nearly six months longer. Dr. Stillman sent us a series of roentgenograms taken in February, 1923, showing a perfectly normal condition. Her general and local condition has remained normal up to the present time, and there is no evidence whatever of a recurrence, now more than four years later. She was personally examined by one of us (W. B. C.) in May, 1926, and no evidence of disease could be found.

The microscopic report of Dr. F. S. Mandlebaum of Mount Sinai Hospital, March 30, was: "Microscopic examination of tumor removed from tibia shows an osteosarcoma, not the so-called giant cell sarcoma. The small specimen excised from the periosteum is free of tumor." Dr. Ewing's diagnosis was giant cell sarcoma.

CASE 46.—*Central sarcoma of tibia; clinical and roentgen-ray diagnosis: giant cell sarcoma; microscopic diagnosis, telangiectatic sarcoma.*

M. G., a woman, aged 35, with a negative family history and general health good, had a history of repeated local trauma. In May, 1920, the patient was injured in a taxicab collision; there was no definite local injury. In May, 1921, she fell, injuring her left knee, two months after which she noticed pain and swelling. In December, 1921, she was treated by baking and massage, and in the following March the leg was put in a plaster cast, which was worn for two months.

The patient was admitted to the Memorial Hospital, June 13, 1922, at which time physical examination showed a large tumor of the lower end of the femur apparently of central origin. The roentgen-ray diagnosis was giant cell sarcoma. A large dose of radium in the form of a pack (6,249 millicurie hours at 6 cm. distance) was immediately applied and in addition she received a brief course of toxins (thirteen injections in three weeks). This was supplemented by four exposures of high voltage roentgen rays. May 30, 1924, when she was readmitted to the Memorial Hospital, physical examination showed the tumor to have markedly increased in size; there was evidence of a pathologic fracture; the patient had been unable to walk for the last eight months. June 5, the leg was amputated.

The pathologic report of Ewing was: "The tumor occupies the upper end of the tibia. It measures 14 cm. long by 15 cm. wide by 15 cm. anteroposterior. It shows a bony capsule nearly complete enclosing the whole growth, but crackling in many places. The skin is everywhere intact. On gross section the tumor is found to be composed of a series of cystic cavities, 1 to 4 cm. wide, filled with blood clot and serous fluid, lined by necrotic tumor tissue in rather thin masses. Many of these masses contain bone. The gross appearance indicates necrosis of nearly the whole central mass of the tumor. The supposed growth has been due to progressive aneurysmal dilatation of the dilated sinuses. The joint surface is everywhere smooth but there are numerous small elevations projecting into the joint covered with synovial membrane and hyperemic bone tissue. The shaft of the bone ends sharply at the lower edge of tumor, but blood spaces extend 2 cm. lower in the medullary cavity. The gross diagnosis is telangiectatic osteogenic sarcoma.

Considerable portions of the tumor are composed of giant cell structure in which the giant cells are rather small and few, and supporting cells rather large and hyperchromatic. This type of tissue lines many sinuses. About many sinuses

the cells are quite large and hyperchromatic but nearly as atypical as in ordinary telangiectatic sarcoma. There is much bone formation in small trabeculae and of rather normal appearance. Some areas show much hyaline material. There are no areas of typical malignant osteogenic sarcoma. The impression is drawn that this is mainly a tumor of dilating aneurysmal blood vessels, with giant cell reaction and new, mostly reparative bone formation. The malignancy appears to be mod-

Fig. 66.—Specimen from patient 155 in table 7.

erate. There are no definite radiation changes. The diagnosis is aneurysm of bone with giant cell reaction."

From the roentgen-ray and clinical data, this case was regarded as a typical giant cell sarcoma, but the microscopic examination showed it to be probably a central malignant tumor. July 28, 1926, the patient was alive but in poor health; there was no evidence of lung metastases. The patient was living, November, 1926, with no evidence of metastases.

CASE 47.—*Telangiectatic osteogenic sarcoma of femur; amputation followed by prophylactic toxins; metastasis in lung one year later.*

P. S., a girl, aged 5 years, was admitted to the Memorial Hospital, June 2, 1924. The family history was negative. The first symptom had been pain in the left leg in March, 1924; shortly after, she developed a slight limp. She was admitted to the Long Island City Hospital, but the diagnosis there, even after an exploratory operation, was doubtful. Her condition grew worse rapidly, so much so that it was necessary to give her a blood transfusion, May 22. The patient left the hospital against the advice of the doctors. Shortly after she was admitted to the Memorial Hospital in an almost moribund condition; she had a rapid pulse (170), rapid respiration, and marked edema of the lower end of the leg.

Physical examination at this time revealed a fungating mass 5 by 5 inches (12.7 by 12.7 cm.) in the anterior portion of the left thigh just above the knee at the site of a recent exploration; the wound was packed with gauze to control the oozing which, however, persisted. The clinical diagnosis was osteogenic sarcoma. An immediate amputation was performed by one of us (B. L. C.), followed by a blood transfusion (250 cc. of blood given). The wound healed by primary union and the patient made a rapid recovery. The toxins of erysipelas and *Bacillus prodigiosus* were begun, June 8, and continued for about two months.

The pathologic report of Ewing, June 2, was: "The specimen consists of the left leg amputated at the junction of the upper and middle thirds of the thigh for fungating sarcoma of the left femur. The lower end of the femur is the seat of a tumor 6 by 7 cm., in the end of the diaphysis. The epiphyseal line is intact, apparently normal but ragged. The tumor destroys the outer half of the shaft, fungates through the skin and produces a bulky hemorrhagic mass 8 by 10 cm. outside the skin. Fungation is through an exploratory incision. The marrow cavity for 10 cm. above the tumor is filled with opaque tumor tissue. The central portion of the tumor has been excavated surgically. Both tibial epiphyseal lines appear somewhat ragged but otherwise normal. Injection of the main artery of the leg fills the tumor spaces and cavity very freely. The lower leg is very edematous. The total length of the shaft involved is 15 cm. above the tumor. There is a layer of subperiosteal hard bone, triangular in shape, 7 cm. long, 13 mm. wide below, tapering out to an end above. The whole shaft along this segment is thickened and the marrow cavity is filled with ossifying bone.

Sections show a malignant telangiectatic osteogenic sarcoma. The tissue is made up of dilated blood sinuses of various size, up to 5 and 10 mm., lined by comparatively normal tissue or sometimes by large spindle tumor cells. There is very little giant cell reaction. Between sinuses in many places the tissue is composed of large hyperchromatic tumor cells. There is much production of bone, well formed or osteoid tissue, or decalcifying or hyaline material or fibrous tissue, in all of which there are a moderate number of cells, usually large and hyperchromatic. On the outskirts of the tumor much of the new bone is nearly normal."

The pathologic report is given in full as this is one of the few cases of typical telangiectatic sarcoma reported. The patient continued to do well until July, 1925, when roentgen-ray examination showed definite metastases in the lung. Her general health remained good. The metastases of the lung were more developed in the fall of 1925.

CASE 48.—*Endothelial myeloma; sarcoma of the upper half of femur; microscopic report, plasma cytoma (Mandlebaum), endothelioma (Ewing); controlled for nearly two years by toxins and radium; metastases of brain and abdomen.*

Mrs. L. A. C., a woman, aged 44, was admitted to the Memorial Hospital in July, 1921; the family history was negative. In the fall of 1919, while adjusting

a window shade, the patient fell, striking her hip on the sharp edge of a piece of furniture. In the winter of 1921, she noticed numbness in both feet and began to limp, being obliged to use a cane; she was treated for rheumatism. The condition grew worse during the winter of 1920; in January, 1921, she was treated at the New York Neurological Institute; no roentgenograms were taken. Later she went to the New York Hospital for Deformities and Joint Diseases, where

Fig. 67 (case 156 in table 7).—Periosteal sarcoma of tibia with metastases in lungs, showing remarkable control of primary and secondary growth by roentgen-ray treatment, April, 1926, disease steadily progressing and condition hopeless.

a roentgenogram was taken and a diagnosis of tumor of the femur was made. She went to the Memorial Hospital in February, but her condition was regarded as hopeless and no treatment was advised. In March, 1921, she was referred to Mount Sinai Hospital and was placed under the care of Drs. Howard Lilienthal and H. Neuhof.

An exploratory operation was performed in the latter part of March; the tumor was found to involve the upper portion of the femur; a piece was removed for microscopic examination and pronounced perithelioma by Dr. Mandlebaum. After further study his final diagnosis was plasma cytoma, the tumor originating in the bone marrow and chiefly made up of plasma cells. He believed the tumor to be malignant and of bone marrow origin.

A pathologic fracture occurred while the patient was in Mount Sinai Hospital, followed by complete loss of power in the left leg and partial loss in the right leg, pointing to probable involvement of the spine. The condition was therefore regarded as absolutely hopeless and the patient was referred to the House of Calvary (a home for incurable cancer patients) in the early part of July. The patient's husband, who had been referred to us by Dr. Robert T. Morris, consulted us in the hope that something might be accomplished by the toxin treatment. After obtaining a careful history from Drs. H. Neuhof and Douglas Quick, we gave an absolutely hopeless prognosis, and advised against bringing the patient to the hospital. However, on the urgent plea of the husband, we finally consented to examine the patient. She was then brought in an ambulance to the Memorial Hospital, in July, 1921.

Physical examination on her admission showed a tumor involving the upper half of the left femur; the patient was greatly emaciated and unable to move the left leg; there were marked limitation of motion of the right and numbness in both legs. Examination of the upper third of the left femur showed marked bony enlargement with pathologic fracture; the leg was put up in a Buck's extension; the plaster cast was removed. Roentgen-ray examination showed a tumor involving the upper third of the femur, about 7 inches (17.7 cm.) in length, with a pathologic fracture in the center. The tumor apparently was of central origin, although so much of the bone was destroyed that it was impossible to tell whether the tumor was of periosteal or central origin. The roentgenogram taken on her admission showed that marked increase in the destructive process had taken place since the previous picture taken in March; no picture was taken of the spine.

We still felt that the condition was hopeless and so told her husband; but as the patient had come such a long distance it did not seem right to send her home without any treatment, and so the toxins were started in small doses, which were gradually increased up to the point of producing severe reactions. Marked improvement was noted at the end of two weeks. A roentgenogram taken at the end of the month showed local improvement and no further extension of the disease; there was beginning regeneration of the bone. In the middle of September, 1921, one radium pack treatment was given in addition to the toxins. Union at this time was sufficiently firm to justify removal of Buck's extension, and the leg was put up in plaster-of-paris. By the latter part of November, union was so firm that a Thomas splint was ordered; the patient was then able to get about in a wheel chair; she had gained 20 pounds (9 Kg.) in weight. Roentgen-ray examination, Jan. 19, 1922, showed well marked regeneration of the bone with firm union. The patient gradually recovered the use of her legs and by March, 1922, she was able to walk with the aid of crutches. The toxins were kept up for nearly a year. She was shown before the New York Surgical Society in March, 1923. The microscopic report of Ewing was endothelioma myeloma.

In the fall of 1923 there was evidence of renewed activity of the disease; the patient refused to take further treatment; metastases developed, and she died in December, 1923. In this case we believe that if the patient could have been kept under treatment much longer, instead of stopping at the end of six months, the result might have been different.

While the following is not strictly speaking a long bone case, in view of the recent interest displayed in this type of case we have thought it worthy of brief mention here:[24]

CASE 49.—*Endothelioma or endothelial myeloma of the os calcis.*

C. T., a boy, aged 9 years, was admitted to the Memorial Hospital under the care of Dr. James Ewing, Oct. 3, 1923. In October, 1922, the patient felt a severe pain in the left heel which lasted for three days and then disappeared. Three months later it returned and again disappeared. In March, 1923, he had another attack of pain in the same locality immediately followed by the appearance of

Fig. 68.—Osteomyelitis following trauma closely simulating sarcoma.

a diffuse swelling. In September, 1923, he was operated on by Dr. J. F. Thompson of Galveston, Texas, who removed the entire tumor which was found to involve a portion of the os calcis. A section was sent to Dr. Ewing for microscoic examination, and he pronounced it an endothelial myeloma. Roentgen-ray examination at the time of the patient's entrance to the Memorial Hospital showed an osteomyelitis with no new bone formation. Roentgenograms of the chest were negative.

24. This patient was under the care of Dr. James Ewing and we are indebted to him for the history and illustrations. The case is of unusual interest because it showed the most widespread generalization that we have ever observed.

From Oct. 23, 1923, to May 12, 1924, the patient received nine exposures of low voltage roentgen rays. In addition the radium pack was applied, 10,000 millicurie hours at 10 cm. distance over three different areas, Feb. 3, 1924, making a total of 30,000 millicurie hours; April 15, he received 37,000 millicurie hours at 10 cm. distance and, April 21, he received 5,000 millicurie hours over two different areas (total 10,000 millicurie hours), making a grand total of 77,000 millicurie hours.

The patient did well until February, 1924, when the swelling of the ankle showed marked increase in size and there was evidence of enlargement of the inguinal glands. Pain soon developed throughout the entire body, and roentgen-ray examination in May, 1924, showed evidence of general metastases. The patient died May 14, 1924. A necropsy was performed, revealing very extensive metastases in nearly every bone and organ.

CASE 50.—*Osteogenic sarcoma of femur; treated with high voltage roentgen rays without control of disease; rapid progress of disease.*

P. G., a girl, aged 14½ years, with a negative family history, had no history of trauma. In September, 1924, she first felt pain in the lower end of the left thigh; this was not severe at first, but about two months later it became more so, causing the patient to limp. She was soon confined to bed and was treated with local applications. A physician was then consulted, who called Dr. L. T. LeWald in consultation; the latter made a diagnosis of osteogenic sarcoma. She was treated with high voltage roentgen rays, two exposures one hour each over the tumor, and one treatment over the chest anteriorly. The pain became so intense as to keep her awake nights. Jan. 21, 1925, she was admitted to the Memorial Hospital, at which time physical examination showed a large, fusiform swelling of the lower fourth of the left thigh, fixed to and apparently arising from the femur; it was extremely tender to touch. The left leg could not be fully extended. There also was an enlargement of the head of the left tibia. Roentgen-ray examination by Dr. R. E. Herendeen showed an osteogenic sarcoma of the distal third of the left femur, with no evidence of metastases in the lungs.

February 11, a ligation of the femoral artery was done by Dr. F. E. Adair.

Roentgen-ray examination, February 28, showed evidence of considerable increase in the size of the tumor of the knee when compared with previous films; there was no definite evidence of lung metastases. The patient was treated with high voltage roentgen rays to the chest and femur for a period ranging from January 26 to June 3, 1925. Roentgen-ray examination, May 18, revealed evidence of considerable increase in ossification of the tumor, which appeared to be very definitely encapsulated. The roentgenogram of the chest revealed evidence of large metastatic tumors. She grew worse rapidly and died, July 4, 1925.

In order to show the striking results obtained in inoperable malignant sarcoma of other bones, we have included the following three cases (cases 51, 52 and 53) but they are not strictly speaking long bone cases.

CASE 51.—*Osteogenic sarcoma of first rib; clinical and roentgen-ray diagnosis; radium and toxin treatment, patient well eight years later.*

H. M., a girl, aged 15 years, was referred to us by Dr. John H. Gibbon of Philadelphia in March, 1917. One year before the patient had what was supposedly an attack of influenza; following this she was subject to a recurrence of pain in the left shoulder. In November, 1916, she had a neuritis-like pain in the left shoulder which lasted for about one week. In the latter part of

February, 1917, she had a similar attack of pain in the same shoulder, extending over the pectoral muscles and around the clavicle and scapula; there was no fever. One week later, there was diminished resonance at the base of the left lung; this was thought to be a pleural effusion; there did not seem to be any acute pleurisy. On the following day, the temperature rose to 100 F. and there was a distinct effusion at the base of the left lung. This cleared up in a few days and the patient was taken to Bryn Mawr Hospital for a roentgenogram of the chest.

Roentgen-ray examination showed in front of the apex of the left lung extending outward, from the vertebral column, a distinct tumor shadow which was nonpulsating and involved the first rib. There was a slight vocal fremitus increase at the apex of the lung.

The patient consulted Dr. Gibbon, who made a diagnosis of inoperable sarcoma of the first rib; this diagnosis was confirmed by Drs. James Alexander Miller and Douglas Quick of New York, who also examined the patient. She was admitted to the Memorial Hospital, March 26, at which time, physical examination showed a tumor of the first rib about 3 inches (7.6 cm.) in diameter. Roentgen-ray examination by Dr. Quick showed "a rarefaction and destruction of the posterior half of the first rib on the left side. Associated with and apparently attached to this was a tumor mass which filled up the left apex and extended a half inch below the level of the clavicle anteriorly. This mass was encapsulated below; the clavicle was normal throughout; the glands were enlarged; there were râles in both lungs. The roentgen-ray diagnosis was periosteal sarcoma of the first rib of the left side with an attached tumor of the left apex and metastases in the lung roots."

From March, 1917, to March, 1918, she received a total of 17,680 millicurie hours of radium. The mixed toxins were begun, April 1, dose of one-fourth minim, and steadily increased during the next two months up to 8 minims; this dose produced a chill and temperature of 103 F. The injections were kept up at home for nearly a year. The patient made a complete recovery, and is well at the present time, with no evidence of a recurrence, more than eight years later. Roentgenograms of the chest were taken every year for a number of years; the last one, taken in 1926, showed that the tumor had almost entirely disappeared. The patient is in good health in July, 1926, nine years later.

CASE 52.—*Sarcoma of seventh and eighth ribs; disease controlled by roentgen ray and toxins.*

Mrs. J. D. F., a woman, aged 28, with a negative family history, fell downstairs in 1908; no pain followed. Since 1915 she felt pain in the right side of the chest; there was never anything palpable externally. In 1919 she consulted Dr. Jerome B. Cook of St. Louis, who had a fluoroscopic examination made; this proved negative. In May, 1922, she felt pain just below the right breast, radiating through to the back; this was worse at night. Dr. Cook had some roentgenograms made which showed a tumor about 3 inches (7.6 cm.) in diameter, involving the seventh and eighth ribs, chiefly the latter, situated about 2 inches (5 cm.) from the median line. There was apparently a pathologic fracture.

An exploratory operation was performed by Dr. Cook in June, 1922. A piece of tissue was removed and pronounced, by Dr. S. E. Newman, a round and spindle cell sarcoma. This microscopic diagnosis was confirmed by Dr. James Ewing.

A roentgen-ray examination was made by Dr. P. S. Schnoebelen of the Jewish Hospital of St. Louis, October 10; his report was: "This skiagraph shows a

destructive process of the eighth rib, which is less dense than in previous films. This skiagraph also shows evidence of reproduction of the vertebral end of the rib. There appears to be some involvement of the seventh and ninth ribs; this involvement was also observed in the previous films, but not as clearly as in this skiagraph. The diagnosis is sarcoma of the eighth rib, which shows definite bone production."

There was no evidence of lung involvement. The patient had been receiving roentgen-ray therapy at the Jewish Hospital. She was referred to us by Dr. Cook, Dec. 4, 1922. We advised supplementing the roentgen rays with injections of the mixed toxins of erysipelas and *Bacillus prodigiosus*. These injections were begun at once and continued at home by Dr. Cook under our direction until November, 1923, or for nearly one year. A roentgenogram taken in July, 1925, showed the disease to be apparently under complete control. The patient's general health was excellent. She was well in April, 1926, after nearly four years.

CASE 53.—*Periosteal sarcoma of the mastoid; treated with toxins and roentgen rays; patient well ten years later.*

G. P., a boy, aged 14 years, was referred to us by Dr. F. B. Lund of Boston, Aug. 14, 1916. A tumor just behind the ear had been excised by the local physician in December, 1915; the clinical diagnosis was a wen; the microscopic diagnosis, a rapidly growing sarcoma with numerous mitotic figures. A slight recurrence took place early in January, 1916. The patient was seen by Dr. H. A. Kelly, who believed the growth could be controlled by radium. Two radium treatments were given by Dr. Kelly. The disease again rapidly recurred and in February, Dr. Lund excised the growth, removing the outer table of the skull. The recurrence had taken place in the scar of the former operation; the growth apparently originated in the periosteum. Another recurrence took place some time later and, June 1, a third operation was performed by Dr. Lund, who opened some mastoid cells. This growth was in front of the one formerly removed and was located nearer the ear. "In cutting beneath it some of the cells were spilled." The growth appeared encapsulated, but was very soft and jelly-like. The disease again recurred, this time nearer the ear, and a fourth operation was performed by Dr. Lund, who opened up the mastoid cells extensively and went into the mastoid antrum.

Shortly after the operation, Dr. Lund started the patient on mixed toxins, beginning with one-half minim once a week and gradually increasing the dose up to 5 minims, without obtaining a reaction. August 14, the patient was referred to us for further toxin treatment; he remained at the hospital for about two months, during which time he received twenty injections, the dose being increased to the point of producing a reaction temperature of 103 F. During the early part of his stay he was given two or three roentgen-ray treatments over the mastoid region.

Physical examination at the time of his entrance to the Memorial Hospital showed in the center of the cicatrix just behind the mastoid region an area about an inch in diameter which was believed to be a recurrence. The toxins were kept up for nearly a year by the patient's home physician, the patient coming down and reporting to us for examination and direction at frequent intervals. He is in excellent condition at the present time, ten years later.

In this case the microscopic diagnosis of Dr. E. B. Mallory was periosteal sarcoma; of Dr. James Ewing, periosteal osteogenic sarcoma.

CASE 54.—*Endothelial myeloma of clavicle with metastases in cervical spine; recovery under radium treatment alone; patient well four years; died in June, 1925 (cause of death not definitely known, possibly due to metastases); (case 196, Bone Sarcoma Registry, and case 5, Conner [Endothelial Myeloma, Ewing, Arch. Surg.* **12**:*789, 1926]).*

M. K., a woman, aged 30, with a negative family history, had no history of antecedent trauma. In July, 1920, she had a "stiff neck"; this was followed shortly after by a swelling in the left supraclavicular region. She had neuralgic pain in the back of the head and in both arms and hands. She was admitted to Memorial Hospital, March 21, 1921, at which time physical examination showed a swelling the size of a goose egg over the inner end of the left clavicle; it was firm in consistency, definitely circumscribed, was fixed to and apparently arose from the clavicle. There also was a diffuse swelling over the area from the third to the fifth cervical vertebrae, extending from 4 to 5 cm. to the left of the median line; there was some limitation of the motion of the neck. The clinical diagnosis was osteogenic sarcoma of the clavicle with metastases to the cervical vertebrae. Roentgen-ray examination showed evidence of a destructive process in the sternal end of the left clavicle and in the body and transverse process of the left side in the sixth cervical vertebra. The character of this process in the clavicle, from the roentgen-ray standpoint alone, closely simulated that noted in another case of endothelioma of the radius.

From March 23, 1921, to April 1, 1922, the patient received five radium pack treatments applied at 6 cm. distance, a total of 34,050 millicurie hours. She had one roentgen-ray treatment, July 13, 1923. She remained well for four years. June 20, 1925, after about a week's illness, the patient died; the cause of her death is not definitely known; possibly it was due to metastases. The physician who attended her during the last week stated that she complained of severe headache, had a rapid pulse (140), a temperature of only 100, suffered from nausea and vomiting, and held her head to one side. Her family physician, Dr. F. Holden, stated that she died of cerebral meningitis induced by making a visit to the hospital on a hot day. It was impossible to ascertain her physical condition for a few months prior to this attack.

Dr. James Ewing's microscopic report on the specimen removed at biopsy was: "The tissue is composed of closely packed cells without uniform stroma. The cells are small, round or polyhedral; they show features of endothelial cells, but are not typical of endothelioma. It may be myeloma or endothelioma."

The remaining cases will be found in the accompanying tables.

OVERGROWTH OF THE LONG BONES OF THE LOWER EXTREMITY

REPORT OF THREE CASES *

MAXWELL HARBIN, M.D.
CLEVELAND

Overgrowth of the long bones resulting in asymmetry is an old observation. Since the roentgen ray has come into general use there have been a greater number of case reports with more accurate observations than formerly. The roentgen ray has been the means, furthermore, of conducting experimentation in an effort to explain the etiologic factors.

The purpose of this article is to describe three cases of overgrowth of the lower extremity, with a distinctly different etiologic factor in each case. All represent an involvement of the tibia in children between the ages of 12 and 14 years.

FACTORS THAT INFLUENCE THE GROWTH OF NORMAL BONE

Normal growth of bone varies with the physiologic demand of the organism for it. Nature seems to provide some mechanism whereby a constant symmetrical progression takes place. Osteoblastic cells located on the proximal portion of the epiphysial line have the quality of proliferation in a linear fashion, resulting in growth in the long axis, while the periosteal cells contribute to enlargement in a transverse diameter.

It seems that the activity of the osteogenic cells may depend on a chemical stimulus which exerts its effect on the epiphyses. The relationship, however, of blood supply is perhaps of greatest importance and its variation serves to explain certain abnormal changes in growth. The experimental studies of Haas [1] have demonstrated the importance of the integrity of the vascular supply to normal longitudinal growth.

FACTORS THAT PRODUCE ABNORMAL GROWTH OF BONE

Various diseases of the bone such as rickets, osteomalacia, osteitis deformans and syphilis, chronic or acute illness, chronic infections localized in or about the metaphyseal portion of the long bones, the action of various glands of internal secretion, trauma and the influences of the nervous system may alter the growth of bones. Perhaps one of the most common types of overgrowth of a single extremity and sometimes of a single bone is that which occurs in adolescents who have

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* From the Department of Surgery of the Lakeside Hospital and the Western Reserve University School of Medicine.

1. Haas, S. L.: The Relation of Blood Supply to Longitudinal Growth of Bone, Am. J. Orth. Surg. **15**:157 (March) 1917.

a chronic osteomyelitis adjacent to an epiphysis without actual invasion of the epiphysis itself. This differentiation is most important since it is my impression that even an invasion of the epiphysis by an avirulent organism or the infliction of a minimum of trauma will always retard rather than accentuate cell proliferation.

Proof of this is well illustrated in the following experiment:

One cubic millimeter of a washed staphylococcus culture of a known low virulence[2] and a bacterial count of 5 per high power field was injected into a 3 months' old dog. The wound healed without suppuration. The animal was followed for six months, roentgenograms being taken at intervals. There was moderate atrophy of the bones of the entire right leg with rarefaction throughout the entire lateral half of the epiphysis, and at the end of six months the femur showed 2.3 cm. shortening. There was no compensatory lengthening of the fibula on the same extremity.

When, however, infection involves the shaft of the bone with extension to the metaphyseal portion without invasion of the epiphyses itself and the necrosis is a slow progressive affair, lengthening of the part sometimes occurs.

Ollier reports a central osteitis of the tibia in a child with a dormant necrosis of the bone which induced 6 cm. lengthening of the shaft.

CASE 1.—A white girl, aged 14, received a slight abrasion of the left lower leg four years before admission; shortly afterward pain and swelling developed over the midtibia with fever. The tibia was incised and drained, and the wound healed after a period of several weeks. One year later the wound broke down, and it discharged for the following two years. The patient treated herself by changing dressings. One year before this examination, she entered the Lakeside Hospital because of pain and tenderness over the mesial aspect of the lower part of the left thigh and a discharging sinus on the internal upper portion of the lower part of the leg. There was swelling around the knee with ballottement of the patella. Saucerization of the infected area of the upper part of the tibia and lower portion of the femur resulted in an early relief of signs and symptoms. On final admission to the dispensary, the patient's general condition was excellent. Physical examination showed multiple healed linear scars above and below the left knee and normal range of motion. There was an increase of 2.5 cm. in length of the left tibia, measured from the internal joint space to the malleolus, with moderate relaxation of the joint capsule, as evidenced by an increase of 20 degrees in lateral mobility. The femora were equal in length.

The roentgenograms (fig. 1) showed the tibial and femoral epiphysial structures to be normal. There was an operative defect on the anterior upper third of the left tibia with perhaps some thickening of the posterior ostium beneath this area.

Congenital syphilis occasionally produces a rather unusual manifestation of bone growth disturbance whereby the bones of one extremity show a symmetrical overgrowth. Wilhelm[3] believes this overgrowth

2. The dog has a high immunity to staphylococcus.

3. Wilhelm, S. F.: Ostitis Fibrosa and Hyperostotic Form of Bone Syphilis, Surg. Gynec. Obst. **41**:624 (Nov.) 1925.

to be the result of stimulation of the epiphyses by the syphilitic osteo-periostitis, being analogous to the increase in length of the shaft in other diseases that occur during the period of growth.

CASE 2.—A white American boy, aged 13 years, was admitted to the hospital in August, 1925, with the complaint of awkwardness and lack of sex development. During the previous three years he had failed in his school work; prior to this he had been quite apt and had made his grades. Two years before admission, he fell a distance of 30 feet and sustained a compound fracture of the left forearm. He was treated at the Cleveland City Hospital, where the history of scaling of

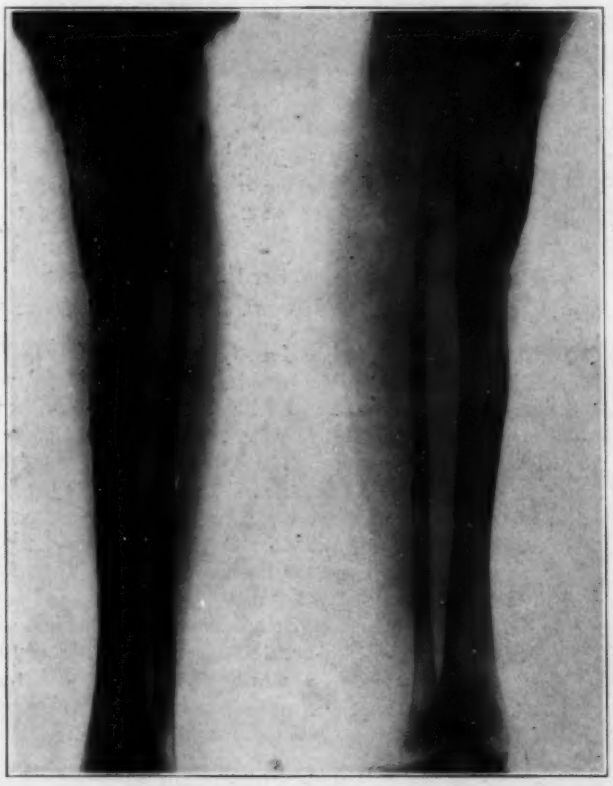

Fig. 1 (case 1).—Right tibia and fibula showing operative defect in tibia.

the palms and soles was obtained; the blood examination showed a four plus Wassermann reaction. The fractured radius and ulnar healed satisfactorily within six weeks, after which he was given antisyphilitic treatment regularly over a period of six months. The past history was unimportant, while the family history revealed that the parents were syphilitic.

The results of the physical examination were unimportant except for the observation of a few scattered, enlarged lymph glands in the posterior cervical region and a convergent strabismus of the right eye. The right lower leg showed some anterior thickening over the tibia. The right tibia measured, from the

internal joint space to the malleolus, 3 cm. longer than its neighbor, with 1 cm. increase in the circumference of the left calf. The reflexes were normal. The blood and spinal fluid were strongly positive. The urine was normal.

The roentgenograms (fig. 2) of the right tibia and fibula presented a uniform enlargement both in circumference and in length; the epiphyses showed no abnormal change.

The most interesting and at the same time a more unusual type of overgrowth of a long bone occurs coincident with nevus and elephantoid subcutaneous tissue. Congenital hemihypertrophy of the body is not uncommon and many cases have been reported, particularly in the French literature, but hypertrophy of a single extremity has been reported in only a few instances.

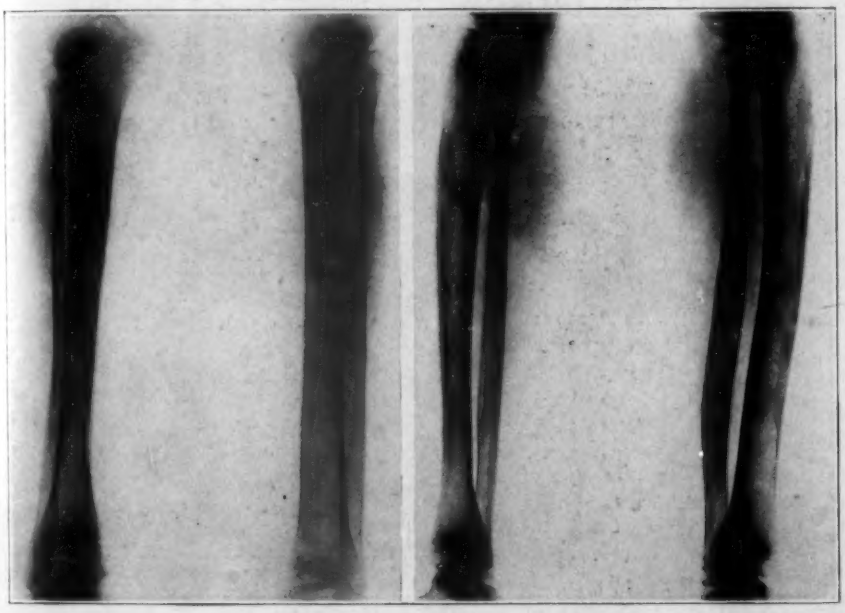

Fig. 2 (case 2).—Right and left tibia and fibula, showing contrast in length and size.

CASE 3.—An Italian girl, aged 12 years, was admitted to the Lakeside Hospital, March 20, 1926, with the complaint of swelling of the left leg and foot. She was the fifth child, born at term following a normal labor. At the age of 2 years she had scarlet fever, at 5 measles, at 6 pertussis, and at 8 pneumonia. She did not walk until 3 years of age. The family history was unimportant.

A few days after birth a brownish pigmentation was noted on the inner side of the left leg, and the mother thought that the lower part of the leg and the foot were somewhat enlarged. This enlargement of the leg had steadily increased until the present time, although there had never been any restriction of activity, or pain.

Physical examination showed a girl of definitely retarded mentality. The eyes presented an internal strabismus; the teeth were soft and the incisors showed notching. The chest was asymmetrical, with prominence of the sternum of the pigeon breast type and a left dorsal right lumbar scoliosis with rotation. The heart and abdomen were normal.

The lower part of the left leg (figs. 3 and 4) appeared much larger than the right, with a marked redundancy of the subcutaneous tissues extending from the knee to the toes. The subcutaneous tissue was soft and flabby and seemed to be differentiated from the muscle planes; the skin was thrown into folds along the outer border of the foot. There was definite increase in the size and number of the veins over the inner aspect of the lower part of the left leg. An irregular, brownish, nonelevated area of pigmentation extended from the groin to the internal aspect of the ankle. Motor function of all the muscles of the lower part

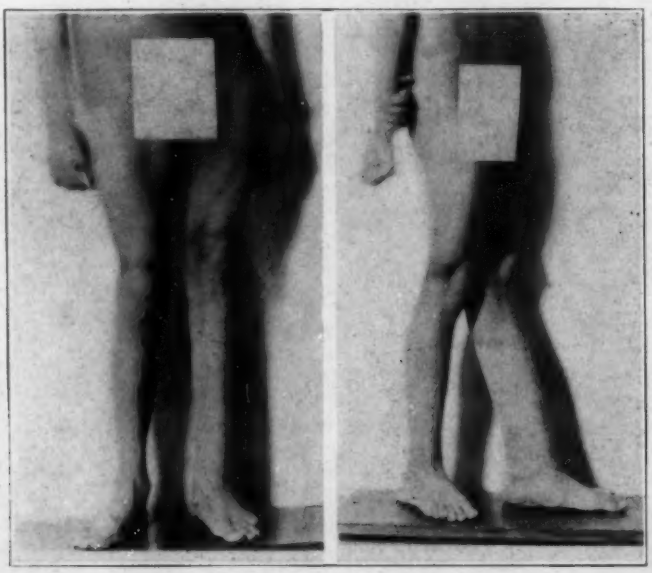

Fig. 3 (case 3).—Elephantoid enlargement of the lower part of the left leg, with tilting of pelvis.

of the leg was markedly diminished, with anterior bowing in the lower third of the tibia. The pulsation of the left dorsalis pedis artery was equal in force and volume to that of the right. The reflexes and sensation were normal.

The measurement of the left tibia from the internal joint space to the malleolus was 3.5 cm. greater than the right. The thighs were equal in size. The circumference of the right knee was 29 cm.; the left knee, 29 cm.; the left calf, 27 cm.; the right calf, 25 cm.; the right ankle, 20 cm.; the left ankle, 28 cm.; the left foot at the scaphoid, 21 cm., and the right foot at the scaphoid, 19.5 cm.

The blood Wassermann reaction was negative on two examinations. The hemoglobin content was 90 (Tallqvist); the white blood cells totaled 8,400. The urine was normal.

The roentgenograms (fig. 5) gave evidence of the increased lengthening of the left tibia and thickening of the anterior cortex similar to that seen in syphilis.

The epiphysial lines of the left tibia were distinctly less clear cut than those of the right. The spine showed an irregular fusion of the fourth and fifth dorsal segments. In view of the increased lengthening of the tibia and the redundancy of the subcutaneous tissue, the child was operated on, March 30, 1926.

At operation dense, resistant, fibrous subcutaneous tissue was encountered which cut with some difficulty; there were a moderate number of rather large venous spaces throughout the tissue. There was no involvement of the muscles or fascia. The periosteum over the anterior surface was rather irregular and stripped with difficulty. A piece of subcutaneous tissue was removed for histologic examination. The tibia was shortened 2 cm., with anticipation that the soft tissue might be resected at a second stage. However, on the third day after operation the patient developed a pulmonary complication, and examination of the sputum showed tubercle bacilli. The physical signs cleared up rather rapidly,

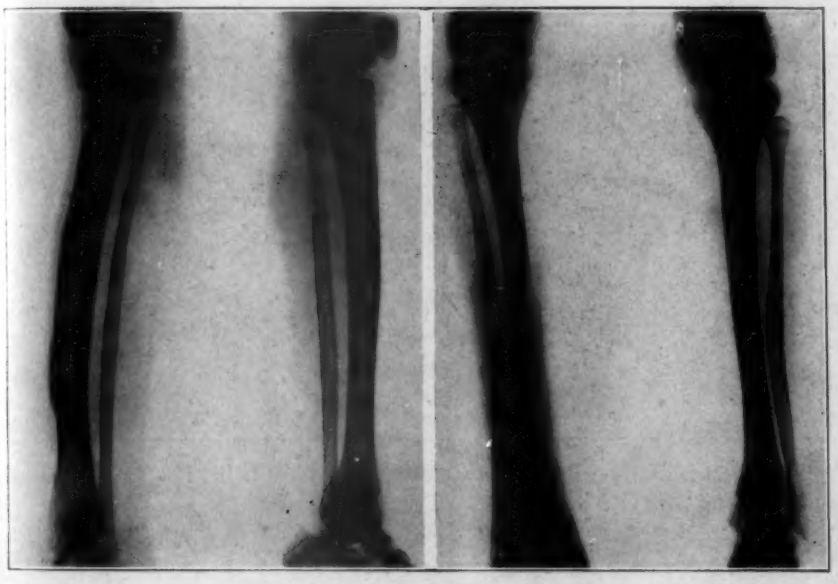

Fig. 4 (case 3).—Anterior cortex of left tibia, showing thickening with elongation.

and she was discharged three weeks after operation. Union of the tibia was firm at the end of eight weeks. It was thought wise in view of the pulmonary disturbance to delay resection of the soft tissue until a later date.

The histologic examination, as reported by Dr. H. T. Karsner, showed considerable fibrous tissue loosely arranged. A few pieces of bone were present in the tissue, together with a few small lymph and venous spaces (fig. 6). The trabeculae of the bone were thicker and closer together than normal, with narrowing of the haversian canals.

Campbell [4] has recently reviewed the literature of congenital hypertrophy and reported a case which was clinically almost similar to the

4. Campbell, W. C.: Congenital Hypertrophy, Surg. Gynec. Obst. **36**:699 (May) 1923.

foregoing except that the tumor tissue lay entirely below the fascial plane, with definite encapsulation.

This disturbance, although commonly spoken of as a congenital hypertrophy, can hardly be such since none of the cases show an increased growth of normal tissue alone, which is seen in the rather more common hemihypertrophies, a number of which have been reported.

Jordan has distinguished two types of enlargement, or elephantiasis: a diffuse neurofibromatosis involving in one type the nerves; in the other, the cutaneous structures and muscle tissue. He believes that the blood vessels give origin to the new tissue. My case would perhaps fall within the latter classification.

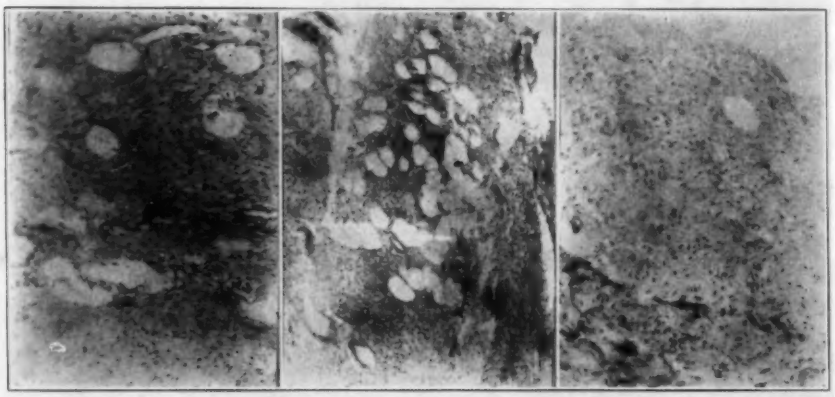

Fig. 5 (case 3).—Subcutaneous tissue; the fibrosis and numerous small lymph channels should be noted.

Telford's[5] case, although one of hemihypertrophy, presented several features in common with this one, viz., nevus, enlarged veins and overgrowth of subcutaneous tissue. He states that the association of localized hypertrophy with nevus and varices, though rare, appears to form a definite clinical entity. The disease when fully developed presents three features, of which the nevus is congenital but more apparent as growth develops, while the varices appear later, and in some instances of the disease are small or entirely lacking.

The limitation of these factors, viz., hypertrophy, nevus and varices, to one extremity is uncommon while unilateral involvement was recognized as early as 1858 by J. Adams, who reported a case in the *Lancet* of that year. The first important reference is the research of Trelat

5. Telford, E. D.: Hemihypertrophy of the Body with Nevus and Varicose Veins, Lancet **2**:1291, 1912.

and Monod,[6] "Asymmetry of the Body," which appeared in 1869; this was followed by articles by Leblanc[7] (1898) and Duplay[8] (1898), and by a remarkably complete article by Kluppel and Trenaunay (1900). Guinaud took the disease as the subject of a Paris thesis in 1901.

Overgrowth of the bone usually predominates although any tissue in the involved area may be hypertrophied. The origin of the disease is in an antenatal pathologic condition. Ewing,[9] quoting from various authors, considers this disease to be a type of cutaneous fibroma, concerned with many complex factors, most of which center in the nervous system.

SUMMARY

Overgrowth of the tibia and fibula in three patients between the ages of 12 and 14 seemed to result from entirely different etiologic factors. The first patient showed an increase in length due to stimulation of the cartilaginous cells of the epiphysial plate from adjacent osteomyelitis without invasion of the epiphysis. The second patient had a history suggesting congenital syphilis without manifestations other than a positive blood Wassermann reaction. The third patient showed a generalized enlargement of the lower part of the left leg, with nevus and enlarged veins apparently of congenital origin.

6. Trelat, V., and Monod, A.: De l'hypertrophie Unilateral Partielle ou totale du corps, Arch. gén. de méd. **10**:257-278, 1888.

7. Leblanc, E.: Contributions à l'étude de l'hypertrophie congenitale unilaterale partielle ou complète: Du rôle probable de la métamérie Ebryonnaire dans son evolution pothogénique, Paris, 1897.

8. Duplay: Hemihypertrophie partielle, Gaz. hebd. de méd. **2**:529-532, 1897.

9. Ewing, James: Neoplastic Diseases, Philadelphia, W. B. Saunders Company.

THIRTY-FIRST REPORT OF PROGRESS IN ORTHOPEDIC SURGERY *

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CONGENITAL CONDITIONS

Treatment of Old Congenital Dislocation of Hip.—Abbott [1] observes that owing to the marked pathologic changes that have taken place in the joint in old congenital dislocation of the hip, reduction by the usual methods is difficult. Skeletal traction is effective in stretching the contracture of soft parts and bringing the head to the level of the acetabulum. Reduction can then be secured by operation. In a series of five successful reductions, the functional result, judged from the standpoint of stability, increased length of limb and improvement in gait, was best in the cases in which bony ankylosis in good position for weight-bearing resulted.

Congenital Dislocation of the Hip: A Method of Determining the Degree of Antetorsion of the Femoral Neck.—Stewart and Karshner [2] suggest that the degree of antetorsion of the neck of the femur can be measured by a means of the fluoroscope and goniometer. The child is placed face down, flat, on the fluoroscopic table. The angle of outward rotation which is necessary to bring the shadow of the neck into alinement with the shadow of the shaft is measured. This angle is subtracted from 90 degrees, giving an angle which represents the antetorsion of the neck of the femur.

Congenital Dislocation of Hip.—Putti,[3] before the Clinical Congress of Surgeons, reported from his records that up to the year 1924, in 1,879 cases, with a total of 2,556 dislocations, heredity seems to play a part in 13 per cent, with a familial factor in 10 per cent. Of these cases,

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* This Report of Progress is based on a review of 230 articles selected from 595 titles dealing with orthopedic surgery appearing in medical literature between March 13 and July 24, 1926. Only the articles that seem to represent progress have been selected for note and comment.

1. Abbott, L. C.: Arch. Surg. **12**:983 (May) 1926.

2. Stewart, S. F., and Karshner, R. G.: Am. J. Roentgenol, **15**:258 (March) 1926.

3. Putti, V.: Surg. Gynec. Obst. **42**:449 (April) 1926.

the deformity occurred in 84.9 per cent females and in 15.1 per cent males. Sixty per cent of the dislocations were single, and 39 per cent were double. Geographically, in Italy it was frequent in the northern provinces, rare in the south and almost unknown in Sicily. The dislocation can result from a number of factors, of which the mechanical is without doubt the most frequent, if not the only cause. The earliest possible diagnosis, even before the child begins to walk, is of great importance. If the dislocation is unilateral, the cutaneous creases of the thigh evident in the infant are not symmetrical, and are displaced proximally on the dislocated side; the inguinal and gluteal pleats are deeper and longer than on the normal side. The outline of the dislocated hip is more prominent. The luxated limb has a tendency toward external rotation. Abduction is slightly diminished. Shortening is nearly always minimal, but appreciable. If the dislocation is bilateral, there is no difference in length of limb, but the pelvis appears enlarged because of the projection of the trochanters, the buttocks are flattened, and the limbs may not be normally abducted. Putti's experience has led him to be conservative in treatment, the bloodless method being used in all cases except those in which the reduction cannot be obtained in this way. This occurs in 5 per cent of the cases. The results in 700 cases in which treatment was given in the year 1923 show functional and anatomic success in about 80 per cent in the single and in 60 per cent in the double dislocations. On the basis of 1,879 cases with 2,556 dislocations, the results were successful in 90 per cent of the single and 65 per cent of the double cases. Anterior transposition, particularly in bilateral cases, may sometimes produce results functionally as satisfactory as those which are anatomically perfect. Putti believes that the treatment will be more successful when it becomes generally possible to begin treatment at an earlier age than is now the case.

Treatment of Congenital Dislocation of the Hips by Early Mobilization.—Up to 4 or 5 years of age, Ducroquet [4] has found that the results of reduction are remarkably successful. He treated 300 patients successfully, but later the reduction offered great difficulties. It is only in children under 5 years of age that a new joint cavity is easily formed. The retraction of the ligaments is greater as the child grows and causes an increasing obstacle to reduction. There are two opposing factors, the difficulty and slowness of forming a new cavity and the early and firm retraction of the ligaments. To obviate the development of joint stiffness, active motion should be employed, retaining the stability of reduction intact. The technic is as follows: After reduction is obtained, the thigh is covered on its anterior surface by large pieces of cotton. This cotton is cut in triangular form with the base at the level of the knee, a

4. Ducroquet, R.: Arch. franco-belges de chir. **28**:1030 (Dec.) 1925.

bandage maintaining the cotton. A plaster cast is then applied, a window being made at the level of the knee. In one or two months the stage of complete immobilization is passed, the cotton is easily removed, and a certain mobility is possible, depending on the amount of cotton used at the time of reduction. This mobility in one plane offers no danger to maintaining reduction. The movements are first started by the parents, and become active eight or fifteen days later. The movements are easily executed, as the thigh is free in the cast. Plaster casts for the second and third position are made on the same principle. Mobilization is allowed from the first day. When the reduction is completed and all plaster casts are taken off, the patient is put to bed for one month, walking with crutches being allowed. Finally, one month and a half after removal of the plaster, all supporting apparatus is abolished.

[ED. NOTE.—We believe that Putti has formulated a most important rule in the treatment of congenital dislocation—early recognition and early reduction—meaning by this that better results than those now secured depend on earlier reduction. This fact should be of interest to both obstetricians and pediatricians.]

TUBERCULOSIS

Ankylosing Operations on the Tuberculous Spine: A Study of Fifty-Three Cases.—Ely [5] asserts that the nonoperative treatment of the tuberculous spine is uncertain, takes years and is always followed by marked deformity. He prefers the Hibbs operation, followed by recumbency on the side or back for six weeks, then a brace for six months. He makes a careful study of the results in fifty-three cases and reports a cure in twenty-eight. This cure or quiescence of the disease is accomplished by a bony fixation which precludes all motion in the diseased parts, carrying out nature's methods of healing tuberculosis of the bones. All patients, children and adults, even those with active sinuses, may benefit by operation. The only contraindication is a poor general condition. If the operation is not successful, it should be revised or more thoroughly performed at a second attempt. A break in the graft is the most common reason for failure.

Pott's Disease.—Rollier,[6] in all cases of spondylitis, combines with the sun cure immobilization in the horizontal position until complete healing of the diseased vertebrae is demonstrated by the roentgenogram; i. e., recalcification of the diseased area and reconstruction of the bone structure with block formation. When the roentgen-ray observations confirm the clinical reports, and when there is complete disappearance of pain, whether on pressure or on tapping in the long axis, and the

5. Ely, L. W.: J. A. M. A. **86**:1748 (June 5) 1926.
6. Rollier, A.: J. Bone & Joint Surg. **8**:360 (April) 1926.

reflexes are normal, the patient is allowed to be up. This result will be obtained in two years from the beginning of the cure. Patients with a closed spondylitis may expect without exception a certain cure by this treatment, but the prognosis in cases with mixed infection is much more unfavorable. Rollier is a determined opponent to the use of plaster apparatus. He advises corsets of celluloid, freely perforated, or linen reinforced with steel. These are made from plaster casts, and should be worn for a year. After cure, the patient should continue his sun baths at home.

Nonspecific Cold Abscesses.—Melchior [7] states that genuine tuberculous abscesses frequently have all the characteristics of hot abscesses. On the other hand, one frequently finds cold abscesses of nontuberculous nature. Such cases are found following osteomyelitis, typhoid fever, bullet wounds or wounds caused by other foreign bodies; likewise, in empyema of the gallbladder, abscesses of the sweat glands or lymphadenitis. He reports four cases of multiple abscesses with typical signs of cold abscess, showing staphylococci exclusively. The granulation tissue revealed no traces of tuberculosis on microscopic study.

Rheumatism of Tuberculous Nature.—Harvier [8] reports a case of rheumatism of tuberculous origin in a patient, aged 40, who developed chronic rheumatism after three acute attacks, twenty-three, four and three years before, respectively. Roentgenograms demonstrated lesions of the joints and bones. Repeated bronchitis and anal fistula were among the signs suggesting the diagnosis of tuberculosis. Inoculation of guinea-pigs with the effusion from the knee joint proved that the fluid contained tubercle bacilli.

[ED. NOTE.—Why call this rheumatism? Ely and Rollier present two diametrically opposed points of view. We cannot agree with Ely that operation is the only cure for Pott's disease, nor do we agree that operation should be performed in the presence of multiple infection. We also feel strongly that children should be treated conservatively. Again, Ely's after-care, six months, seems perhaps to explain why only twenty-eight of fifty-three patients were benefited. Rollier, on the other hand, has the enthusiasm of a propagandist for a special type of so-called cure.]

POLIOMYELITIS

The Surgical Treatment of Dangle-Foot.—Ollerenshaw [9] has operated in nineteen cases of drop-foot by the "bone-stop" method of Campbell. He uses the bone removed from the subastragaloid joint and

7. Melchior, E.: Beitr. z. klin. Chir. **133**:205, 1925.

8. Harvier, P.: Bull. et mém. Soc. méd. d. hôp. de Paris **50**:509 (March 26) 1926.

9. Ollerenshaw, R.: Brit. M. J. **1**:525 (March 20) 1926.

scaphoid bone to establish the bone-block back of the tibia on the os calcis. Two patients have had a secondary operation for repair of the bone-stop, which had fractured after a few months of functional use.

Operation for Dangle-Foot.—Morison and MacKenzie [10] report three cases of dangle-foot in which operations were performed three years previously. The operation consists of making osseous ligaments by transplanting bone and periosteum between the tibia and fibula above and the astragalus and the os calcis below. The resulting fixation in the three cases has been permanent, and roentgenograms show definite bony bridges.

Operation for Abductor Paralysis of Hip.—Colonna [11] has proposed an operation which is said to be of value in cases of paralysis of the hip if the quadriceps femoris muscle is active. It is proposed to take advantage of a portion of the quadriceps femoris muscle by detaching the long head of the rectus femoris from its two origins, and freeing this portion from its bed for a few inches. This long head is then brought through the fascia lata and is placed superficially to the tensor fascia lata, after which it is inserted into the crest of the ilium or fascia covering the paralyzed gluteus medius muscle.

Serum Treatment of Poliomyelitis.—Etienne [12] treated with serum fourteen adults who had acute myelitis. He used Pettit's poliomyelitis antiserum, prepared at the Pasteur Institute in Paris. Eighty cubic centimeters of the serum was given subcutaneously. Slight movements reappeared within forty-eight hours. The patient improved by the fifth day, was able to walk by the twelfth day, and recovery was soon complete. In a subacute case with bladder disturbances and paraplegia, improvement occurred by the third day. A month later the man went back to work. In a case of extensive paraplegia with bulbar involvement, the speech improved and the patient recovered in a few days. A patient, treated with the serum two months after the onset of the disease, began to walk in six days. Similar results were obtained in a case of eleven weeks' standing when treatment was begun. A dose of 300 cc. may sometimes be needed. In cases with prolonged course and successive involvement of the spinal cord, medulla and brain, a total of 2,200 cc. of the serum was required. In recent cases, 100 cc. of the antiserum is the usual dose given by intraspinal injection.

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10. Morison, R., and Mackenzie, W.: Surg. Gynec. Obst. **42**:270 (Feb.) 1926.

11. Colonna, P. C.: J. M. Soc. New Jersey **23**:177 (April) 1926.

12. Etienne, G.: Médecine **7**:349 (Feb.) 1926.

SYPHILIS

Roentgenologic Study of Congenital Syphilis of the Long Bones.—Péhu, Chassard and Mme. Enselme [13] have studied for many years the changes in the long bones due to congenital syphilis which occur in infancy, that is, from birth up to the second year. They divide these into four groups: (1) gummas, which are rare; (2) osteomalacic changes, which represent a dystrophy of the bone, also being rare; (3) the osteochondritis of Weyner-Parrot type, which usually begins in utero about the fifth month of pregnancy, but may be delayed as late as the third month of life; (4) hyperplastic periostitis, which is by far the most frequent manifestation of congenital syphilis, comprising about 80 per cent of their cases. The condition is demonstrated only by a roentgenogram, and the bones of the four extremities are often affected in an exactly similar and symmetrical manner. These changes begin in the first three months of life, and continue until about the eighteenth. It is, therefore, an extra-uterine condition.

PYOGENIC INFECTIONS OF BONES AND JOINTS

The Aspiration of Septic Joints of Low Virulence.—Lonergan [14] gives the details in three typical cases chosen from a large group of septic joints of low virulence observed at the Children's Hospital in Boston. In this group there usually was an initial trauma, followed in a day or two by increasing tenderness, swelling and heat in the joint. There were temperature elevation of from 1 to 4 degrees, a large number of white blood cells and a varying amount of general constitutional reaction. The treatment consisted of immediate aspiration, from which sometimes turbid fluid and sometimes thin pus was obtained. Some of the cultures showed no growth and others a staphylococcus of low virulence. The patients were carefully watched, but no other operative procedure was necessary, and a full return of motion and quick subsidence of local and constitutional symptoms followed.

[ED. NOTE.—These observations of Lonergan are of value as suggesting that in many cases of mild sepsis with joint effusion in children the simple relief of tension may enable the joint tissues successfully to combat bacterial invasion. We strongly emphasize the necessity for hospitalization and close clinical and bacteriologic observation if such a case is to be handled safely.]

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13. Péhu, M.; Chassard, M., and Enselme, J.: J. de radiol. et d'electrol. **10**:54 (Feb.) 1926.

14. Lonergan, R. C.: Boston M. & S. J. **194**:661 (April 15) 1926.

NEOPLASMS

Endothelial Myeloma: Fifty-Four Cases.—Connor [15] finds that there have been sixty-seven cases of Ewing's tumor, designated in this article as endothelial myeloma, recorded in the Registry of Bone Sarcoma of the American College of Surgeons. These constitute about 10 per cent of all cases of bone tumors registered and are reported in full. The belief that these form an entity separable from osteogenic sarcoma is borne out by the characteristics emphasized here, namely, their almost constant location in the shafts of the long bones and in the flat bones where osteogenic sarcoma seldom occurs; their peculiar morphology (the type of cell being easily distinguished from the osteoblast in most cases), and their susceptibility to radium and roentgen-ray treatment. These myelomas occur mainly in children, and many of them are preceded by trauma and by signs of inflammation. Histologically, they may be divided into the angiomatous, the reticular and the diffuse. Their development is slow, with intermittent pain and swelling; they may recede only to return and become progressive. As a final distinguishing point, the therapeutic radium or roentgen-ray test is advocated. This form of tumor, in contrast to osteogenetic sarcoma, usually disappears under the influence of these forces. Connor does not agree with the opinion of Ewing and others that endothelial myeloma arises as a solitary tumor. He believes that the multiple tumors are actual metastases. For this reason, he believes that amputation in the early stages is a form of treatment which should be considered, although apparently radium has cured the condition in several cases. The prognosis, with a combination of surgical intervention and irradiation, is not always death. Patients have lived for five years or longer after treatment.

Angio-Endothelioma of the Bone.—Kolodny [16] analyzes two cases which he believes show that angio-endothelioma of the bone is a true pathologic entity, which, however, is exceedingly rare. The diagnosis of endothelioma of the bone should be made only when all the evidence is clear and conclusive; otherwise, the diagnosis of endothelioma will continue to be the graveyard of those uncommon complex tumors concerning which present knowledge is extremely meager.

Bone Formation in Osteogenetic Sarcoma.—Eising [17] has reached the conclusions (1) that sarcoma in the bone is a malignancy of the softer structures and connective tissues in bone, progressing in the matrix and along the pathway of the haversian canals and blood vessels, and (2) that the new bone proliferation in osteogenic sarcoma is a

15. Connor, C. L.: Arch. Surg. **12**:789 (April) 1926.
16. Kolodny, Anatole: Arch. Surg. **12**:854 (April) 1926.
17. Eising, E. H.: Arch. Surg. **12**:867 (April) 1926.

secondary process, and is the result of an attempt at the establishment of a natural barrier to the intrusion of the neoplastic process.

Registry of Bone Sarcoma.—Codman [18] presents an excellent report of the Registry of Bone Sarcoma. It is divided into two parts: one part contains twenty-five rules for establishing the diagnosis of osteogenetic sarcoma; the other part is a report of thirteen registered cases of "five year cures" analyzed according to these criteria.

Myxochondrosarcoma of the Knee.—Fedeli [19] describes a case of myxochondrosarcoma of the capsule of the knee following trauma. He gives the differential diagnosis and reports on the microscopic appearance after amputation. In making a differential diagnosis from tuberculosis and from acute and chronic inflammatory lesions, he indicates the value of the roentgenograms, the absence of increase in local surface temperature, the retention of movement until the joint lining is involved, the changes in the overlying superficial veins and the character of the swelling.

The Similarity of the Roentgen-Ray Observations in Multiple Myeloma and in Sporotrichosis.—Altschul [20] calls attention to the possibility that the rare condition of sporotrichosis of the bones of the skull may present a roentgen-ray picture almost entirely identical with that found in multiple myeloma of the skull.

VASCULAR DISEASE

Treatment of Thrombo-Angiitis Obliterans by Intravenous Injection of Hypertonic Salt Solution: Preliminary Report.—Silbert [21] asserts that the etiology of this disease is not understood. No satisfactory explanation has yet been given of the peculiar distribution of the disease. Whether the abnormality is primarily one of the blood vessels, of the sympathetic nervous system or of the glands of internal secretion, is yet to be determined. Although the discovery of the real nature of the process is of great importance if a rational therapy is to be evolved, various forms of treatment are being tried. Koga, in 1913, first suggested the intravenous administration of fluids in thrombosis obliterans. At present the author uses a 5 per cent hypertonic solution of sodium chloride, 150 cc., for the first injection and 300 cc. for all subsequent injections. Immediate improvement may occur, but often there is no improvement until a few weeks later. In a series of sixty-six cases, forty-six patients have definitely improved. Repeated intravenous injec-

18. Codman, E. A.: Surg. Gynec. Obst. **42**:381 (March) 1926.
19. Fedeli, F.: Chir d. org. di movimento **10**:209 (Feb.) 1926.
20. Altschul, Walter: Am. J. Roentgenol. **15**:224 (March) 1926.
21. Silbert, Samuel: J. A. M. A. **86**:1759 (June 5) 1926.

tions of hypertonic salt solution have been used in the treatment in sixty-six cases of thrombo-angiitis obliterans. Improvement has resulted in the majority of patients, cessation of pain, increased temperature of the extremity, growth of the nails, healing of the ulcers and the reopening of obliterated vessels. No dangerous reactions or untoward results of any kind have been noted in more than 2,500 injections. Four consecutive successful amputations below the knee have been performed in four advanced cases after preliminary treatment with physiologic sodium chloride solution. If begun before the disease is too far advanced, treatment of thrombo-angiitis obliterans by repeated injections of hypertonic sodium chloride solution will check the progress of the disease and will restore the patient to health and usefulness in the majority of instances.

ARTHRITIS

Pathology and Treatment of Chronic Arthritis.—Pemberton [22] bases his discussion of the pathology and treatment of chronic arthritis on a critical consideration of 1,200 cases. Although treatment of the disease is in the realm of internal medicine, he believes it has received more profitable attention from orthopedic surgeons than from any other group. So much emphasis has been placed on focal infections that the idea has gained ground that treatment in this disease may be successful if the patient is treated by dental, aural, laryngologic or gastro-intestinal specialists. This conception, he points out, is far from adequate, and is responsible for many of the failures to relieve the symptoms. The 400 army cases which he studied carefully provide important data. Forty-six per cent of the patients recovered in the presence of demonstrable foci; 16 per cent recovered after the removal of foci. This significant observation suggests that there are other factors than mere focal infection which play a large rôle in the determination of invalidism or recovery. Twenty per cent of the patients showed a somewhat lowered basal metabolism. The urea and nonprotein nitrogen content of the blood were normal in all the uncomplicated cases, and on many grounds it can be stated with confidence that there is no justification for the old practice of denying these patients the so-called "red" meats. The anemia incidental to arthritis may be aggravated by this unnecessary prohibition. Even after the removal of possibly causative foci, a more or less permanent physiologic change, adequate to perpetuate symptoms, may remain for a long time. Arthritis is only one branch of a large tree, and merely constitutes the surface expression of an underlying pathologic condition. The author considers nearly every case of arthritis which presents serious deformity a reproach to the medical profession, and he

22. Pemberton, R.: W. Virginia M. J. **22**:232 (May) 1926.

believes that the outlook for the arthritic patient who is treated vigorously, and above all intelligently, is growing progressively better.

[ED. NOTE.—We are are in hearty accord with these conceptions of Pemberton. We should continue to remove such easily accessible foci as may play a part in lowering the patient's resistance, but we should consider arthritis as a generalized disease, of which the foci may be a symptom as well as the affected joints. If we examined apparently well persons as carefully as we examine arthritic patients, we should find many such foci, and if we succeed in overcoming the generalized disease many of these suspected foci cease to be important factors, as Pemberton's statistics prove; these may actually disappear as the patient's resistance to bacterial invasion is increased.]

Synovectomy in Chronic Infectious Arthritis.—Swett [23] believes that synovectomy is an operation that warrants further trial in carefully selected cases of chronic infectious arthritis. It may be expected to promote the restoration of function to those joints in which resolution of the exudate has been delayed. It may also prevent the further destruction of the cartilages and the secondary ankylosis which would result from the prolonged presence of large amounts of organized inflammatory exudate. It should be done before bone and cartilage changes occur, in the hope of preventing such changes. Furthermore, bone and cartilage changes do not contraindicate synovectomy, but the resulting benefit may be prejudiced by such changes and to a degree in direct proportion to their extent. These observations are based on an experience of thirty-nine synovectomies in thirty-two patients, one in the wrist, three in the elbow, thirty-two in the knee, one in the hip, one in the finger and one in the ankle.

Calcium Content of Blood in Gout and Arthritis.—From an analysis of the blood in cases of gout and arthritis, Horowitz [24] finds that the estimation of the blood calcium, except in acute gout, whether during attacks or in the intervals, is of no help in distinguishing gout from arthritis.

DISTURBANCES OF THE NERVOUS SYSTEM

Treatment of Spastic Palsy in Children.—Fairbank,[25] whose experience is wide, has written a valuable article on this subject. He believes that in most cases of spastic palsy the intracranial damage has been done before birth, but that enough cases of such a disease as syphilis exist to make it necessary for the surgeon to assure himself that the case is not progressive before he advises operative intervention. In the ordinary case he doubts the value of decompression, as suggested by Sharpe, and he considers that the

23. Swett, P. P.: Am. J. Surg. **40**:49 (March) 1926.
24. Horowitz, P.: Am. J. M. Sc. **171**:560 (April) 1926.
25. Fairbank, H. A. T.: Brit. M. J. **1**:776 (May 1) 1926.

results of ramisection have been almost universally disappointing. In discussing treatment, he agrees with Bankart that massage is of no value. The purpose of all operative treatment is to remove excessive muscle spasm in certain groups, thereby correcting deformity and restoring muscle balance. Operative procedures may be undertaken when the patient is 3 years of age, and he considers that only two types of operation are worth discussing: (1) operations on the tendons and muscles and (2) operations on some of the motor nerve fibers passing to the spastic muscles. The first group of tendon operations includes tendon lengthenings, myotomies and tendon transplantations; the second, Stoffel's operation on the afferent fibers on the basis of the anatomy of the peripheral nerve bundles. His estimation of the relative value of these two types of operation is as follows: After an extensive trial and a review of the results of sixty operations on the internal popliteal nerve, he concludes that for the relief of equinus the nerve operation possesses no advantages over lengthening of the Achilles tendon by open operation. In cases of obstinate knee flexion, he considers that the excision of the appropriate fibers of the sciatic nerve running to the long head of the biceps and the semimembranosus and a portion of the fibers running to the semitendinosus gives better results than operations on the hamstring tendons. He also believes that better results follow excisions of the obturator nerves in cases of severe adduction of the thighs than radical muscle or tendon operations. He attacks the nerves by an abdominal extraperitoneal route. He overcomes severe internal rotations by an attack on the superior gluteal nerve, excising only its terminal portion near the trochanter. He controls severe pronation in the arm by excising some of the fibers of the median nerve running to the pronator radii teres, the flexor carpi radialis and the palmaris. He calls attention to the importance of using a battery to pick out the appropriate fibers, since the arrangement of the bundles of the median nerve has not in his experience been constant. For after-treatment he depends on night retentive apparatus, the usual braces and muscle training. He has noticed that keloid is prone to occur in these cases.

Physiology of the Sympathetic Nervous System in Relation to Ramisection.—Forbes and Cobb [26] doubt whether any success that may follow the operation of ramisection in cases of spastic paraplegia can be ascribed to the operation itself. Many factors may enter into the success of such an operation. In addition to the actual effect of interrupting the sympathetic nerve path, there are other possible causes of improvement, such as exercises, mental suggestion, hospital care and nursing. Some operations have been entirely unsuccessful. The proposal to relieve

26. Forbes, Alexander, and Cobb, Stanley: J. A. M. A. **86**:1884 (June 19) 1926.

spastic paralysis by surgical interruption of the sympathetic nerve innervation of the muscles involved, is based on the theory that a special function designated as "plastic tone" depends on the sympathetic nerve fibers, and that abolition of this plastic tonus will considerably relieve the pathologic spastic condition. Experimental research of many observers has failed to substantiate these observations.

Anatomy of the Sympathetic Nervous System with Reference to Sympathectomy and Ramisection.—Ranson,[27] after discussing the anatomy of the sympathetic nervous system, concludes that no satisfactory explanation has been presented for the hyperemia that follows periarterial sympathectomy, nor for the relief of the pain that some of these patients experience. It is well known that there are sensory fibers supplying the blood vessels, but these for the most part run centrally in the spinal nerves, and there is no reason to believe that they run in the periarterial sympathetic plexuses for any considerable distances.

Danger in Use of Iodized Oil in the Diagnosis of Obstructive Lesions of the Spinal Canal.—Owing to the fact that no unfavorable reports have been made of the use of iodized oil in the diagnosis of obstructive lesions of the spinal canal, Sharpe and Peterson [28] report three cases in which it was used with success as to diagnostic observations, but with aggravation of clinical symptoms and signs. So marked in one case was this aggravation that a laminectomy was performed and two encysted globules of iodized oil surrounded by numerous newly formed adhesions were removed. In all three cases the unabsorbed iodized oil was revealed by the roentgen ray in the spinal canal even after an interval of fifteen months following injection.

GROWTH DISTURBANCES

Achondroplasia.—Giaume [29] reports a case of achondroplasia, and in discussing the etiology of the condition says that while the clinical picture is well known, the etiology remains obscure, as is indicated by the various hypotheses that have been suggested. The theories that have been strenuously and authoritatively advanced, although numerous, may be grouped about three different conceptions, according to which the etiology may be sought in hereditary factors, in endocrine dysfunction and in toxic and infectious influences. He carefully discusses these theories, and then reports a personal observation, from a study of which he offers the following conclusion: On account of the hydramnios of the positive Wassermann reactions in the parents and in the patient, and the evident

27. Ranson, S. W.: J. A. M. A. **86**:1886 (June 19) 1926.

28. Sharpe, William, and Peterson, C. A.: J. Bone & Joint Surg. **8**:348 (April) 1926.

29. Giaume, C.: Pediatria **34**:359 (April 1) 1926.

advantage gained by antisyphilitic treatment, syphilis may be considered as a basic element in the etiology of the author's case. He goes on to say that every toxic or infectious factor, may, perhaps, cause this congenital malformation, acting on the amniotic sac between the fourth and sixth week of fetal development, but that it probably is the syphilitic infection which is more often present and, therefore, that this should always be sought carefully.

Chondrodysplasia.—Cole [30] reports one case of chondrodysplasia and reviews the literature on the subject. He believes that the term "Ollier's disease" is one which is fixed in the literature, but which should be used only to designate the cases of cartilaginous dystrophy with or without cartilaginous tumor formation which show an asymmetrical involvement of the body as the outstanding clinical feature. Chondrodysplasia (a term preferable to dyschondroplasia) is a condition that is usually asymmetrical; but as several symmetrical cases are on record, the term must be broader in its application than as used by Ollier in describing "Ollier's disease."

RICKETS AND METABOLIC DISTURBANCES

The New Haven Demonstration of Community Control of Rickets.—Eliot [31] believes that antirachitic treatment should be begun in the first month of life and continued faithfully for two years. In the temperate zone, rickets is nearly a universal disease among infants, whether breast or artificially fed. The New Haven demonstration was undertaken to show that 90 per cent of the infants seen by roentgen-ray examination showed evidences of slight rickets before they were 6 months of age. When the directions regarding cod liver oil and sun baths were followed regularly, these infants did not develop the slightest evidence of rickets; that is, the disease was controlled. In contrast to this group stands the control series, which showed 18 per cent of moderate or marked rickets at 10 months, 25 per cent at 13 months and 37 per cent at 25 months of age.

Permanent Rickets: Eight Cases.—Hess [32] concludes that recurrences of rickets are frequent, especially during the second year of life. Hence, specific therapy, whether cod liver oil or ultraviolet irradiation, should be continued after all signs and symptoms of rickets have disappeared. Furthermore, cod liver oil should be given not only during the first but also during the second winter. This is advisable, particularly in regard to infants who have had rickets and are therefore susceptible to a recurrence.

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30. Cole, W. H.: Surg. Gynec. Obst. **42**:359 (March) 1926.
31. Eliot, M. M.: Pub. Health J. **17**:114 (March) 1926.
32. Hess, A. F.: Am. J. Dis. Child. **31**:380 (March) 1926.

The Value of Irradiated Cholesterol in the Treatment of Rickets.—Parsons [33] reports a severe case of rickets in which the patient had been under treatment during the greater part of 1925. From April to the beginning of September, the child received cod liver oil as an outpatient, but with only slight improvement. During the last months of the year he was admitted into the hospital, and irradiated cholesterol was administered with the result that the rickets was cured.

Neurologic Symptoms in Osteitis Deformans (Paget's Disease).—Gregg [34] reviews a series of reported cases, making further analysis of the neurologic observations. He states that the disease is not rare, but that since roentgenologic examinations have been made there is a great increase in the number of cases. Early in the disease the patient complains of bone pains due to pressure caused by disturbances of the function of the nerves. Spontaneous fracture, joint pains, motor disturbances, neuralgia and paralysis occur. The diagnosis can generally be made by roentgenograms.

Report of a Case of Solitary Fibrocystic Disease of the Humerus, Exhibiting Spontaneous Resolution; a Review of the Literature; Etiology and Treatment.—Adams,[35] in reporting a case of solitary fibrocystic disease of the humerus exhibiting spontaneous resolutions, observes that the disease seems to form one of the many guises in which defective calcium metabolism disguises itself. He makes three divisions of his subject. 1. Three factors, therefore, enter into the etiology of fibrocystic disease: (*a*) vulnerable formative tissues of the metaphysis, especially at the upper end of the humerus and the extremities of the femur; (*b*) the site of maximum physical stress on bones, that is, near the shoulder, hip and knee, where strong muscles pull and twist, and (*c*) instability of calcium control, owing to defective parathyroid function. 2. The varying degrees to which the skeleton is affected by fibrocystic disease are easily explained. Thus, in the mildest cases there is a temporary disorder affecting one of the particularly susceptible regions, for example, the upper end of the humerus, and subsequent disappearance of the disease. In a moderate deficiency of parathyroid function, a solitary lesion occurs and persists, while in a severe disturbance, multiple foci manifest themselves. Finally, the diffusion of the disease throughout all the bones (von Recklinghausen's disease of bones) may be regarded as a malignant form. 3. In the monosseous type of fibrocystic disease of the bones, spontaneous cure has been known to occur in only about 4 per cent of cases. It remains to be seen whether this percentage can be augmented by the wider adoption of palliative treatment.

33. Parsons, L. G.: Brit. M. J. **1**:519 (March 20) 1926.
34. Gregg, D.: Arch. Neurol. & Psychiat. **15**:613 (May) 1926.
35. Adams, A. W.: Brit. J. Surg. **13**:734 (April) 1926.

Osteomalacia in Kashmir.—Vaughan [36] says that osteomalacia is common in Kashmir. Almost all Kashmiri women who have borne children are affected in some degree, with the exception of the boatman class. The latter women live in the open air on large freight boats, work hard and eat with the men. They are too poor to cook their food, and eat such raw vegetables as cucumbers and tomatoes with their rice. The worst cases are seen in the homes of the wealthy, who keep their women in seclusion, and among those of the poorer classes who do the same. Many deaths take place during childbirth owing to conditions consequent to osteomalacia; as skilled assistance is not available, mother and child often are lost. Rickets is not common in Kashmir.

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36. Vaughan, K.: Brit. M. J. **1**:413 (March 6) 1926.

(To be continued)

ARCHIVES OF SURGERY

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TRANSACTIONS OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

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SEPT. 30, OCT. 1 AND 2, 1926

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BRONCHOGRAPHY

INJECTION OF IODIZED OIL, 40 PER CENT*

J. J. SINGER, M.D.
ST. LOUIS

In the study of the roentgenograms of the chest of patients who have had a bismuth or barium meal for gastro-intestinal study, one occasionally encounters a startling picture of the bronchi outlined by barium. This accident is due to a fistulous tract caused by ulceration of the esophagus into the trachea. It has been noticed in these patients that fits of coughing occur during the swallowing of the barium. We have learned to look for ulceration of the esophagus in patients who suddenly begin to cough during a gastro-intestinal examination.

Jackson [1] of Philadelphia introduced bismuth subcarbonate in finely powdered form through a bronchoscope into the lobe of the lung that he wished to study. He obtained excellent roentgenograms by this method. Owing to the fact that bronchography through a bronchoscope requires the greatest skill, it was natural that such a practice did not become popular. Since the introduction of iodized oil, 40 per cent, as suggested by Sicard and Forestier,[2] we have been able to perform lung mapping without any danger to the patient and with considerable value in diagnosis.

There are five methods of introducing iodized oil, 40 per cent:

1. Through a trocar needle, resembling a tracheotomy tube, into the trachea, under sterile precautions.[3]

2. Under direct laryngoscopic examination with the patient lying on the back, with the head extended over the table.

3. Through the bronchoscope introduced directly into the lung.

4. Through a tracheal catheter introduced under indirect illumination of the larynx.

5. By the injection into the pharynx of 20 cc. of oil, while the patient pulls out his tongue as far as possible. The patient should be trained to take many successive deep breaths following the injection of the oil.

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* From the Department of Medicine and Surgery, Washington University School of Medicine, and Barnes Hospital.

1. Jackson, Chevalier: Bronchoscopy and Esophagoscopy, Philadelphia, W. B. Saunders Company, 1922.

2. Sicard, J. A., and Forestier, J.; General Method of Radiological Exploration with Iodized Oil, Bull. et mém. Soc. méd. d. hôp. de Paris **46**:463 (March 10) 1922.

3. Armand-Delille, P., and Gelston, C. F.: The Diagnosis of Dilatation of the Bronchi in Children by Means of the Injection of Iodinized Oil, Am. J. Dis. Child. **28**:530 (Nov.) 1924.

The iodized oils used were lipiodol (Lafay), which contains 40 per cent of iodine by weight combined with poppy seed oil; and iodipin, which contains 40 per cent by weight combined with sesame oil. Iodipin can be obtained in either 10 per cent or 40 per cent compounds. It is possible that the other oils can be used, but the two mentioned are the oils we use in our work.

It is interesting to know that the iodine is so firmly combined with the oil that the iodine reaction cannot be obtained in patients who are expectorating sputum combined with the oil. Iodized oil is not rapidly broken down in the lungs but may be in the gastro-intestinal tract, when it is swallowed, or when through accident the oil is introduced into the esophagus. Iodism may thus result.

The choice of the five methods of technic in use usually varies with the experience of those interested in the methods. Laryngologists prefer the bronchoscope; pediatricians, the tracheal trocar. Medical men and roentgenologists prefer the intratracheal injection through the mouth. No matter which method is used, approximately from 20 to 40 cc. of the oil must be used to produce suitable roentgenograms.

FIRST METHOD[3]

In the first method, the patient is placed in a horizontal position, preferably on a roentgen-ray table so that after the introduction of oil the roentgenogram can be taken immediately. It has been shown that frequently patients will cough out the oil before the roentgenogram is taken; then the whole operation must be repeated.

The head is placed in hyperextension in order to locate the cartilages more easily. The skin is prepared by the application of tincture of iodine and the operator places himself on the right of the patient, immobilizing the thyroid cartilage between the thumb and the second finger of the left hand, while with the index finger he palpates the cricothyroid membrane. He then rapidly anesthetizes the skin and subcutaneous layers of tissue with procaine hydrochloride, and guided by the left index finger, which has located the correct position, the trocar is forced through the tissues in a plane perpendicular to the larynx. Following this, by movement upward of the plate at the base, the trocar is pushed farther into the trachea, and at the same time becomes parallel with its walls, while the plate rests flat against the neck. When the stilet is withdrawn, a whistling sound of the inspired air denotes a correct position. The syringe containing 5 cc. of procaine hydrochloride is now attached, the head of the patient is slightly withdrawn from its extreme hyperextension in order to prevent the liquid from flowing toward the glottis, and slight pressure exerted to cause its entrance. A forcing out of the piston and the presence of bubbles of air caused by the cough incident to the irritation of the first few drops of the solution confirm the correct position of the trocar in the trachea. Should these indications not be present, one of course suspects a false entry or the presence of a fold of mucous membrane over the opening. A small amount of manipulation of the cannula and the use of the stilet will usually give results fairly quickly.

The initial coughing rapidly abates with the anesthesia of the tracheal mucous membrane. The operator then attaches the syringe containing the iodized oil, 40 per cent, and begins the injection, which should not be too rapid. During the course of the injection or immediately afterward, it is wise to elevate first one side of the patient and then the other in order to facilitate the distribution of the oil. If it is suspected that one side only is affected, the lower position for that side may be maintained entirely. From 8 to 10 cc. of oil suffices, as a rule, to inject the bronchial tree of one lung in children aged from 7 to 14 years, and requires from six to eight minutes or less.

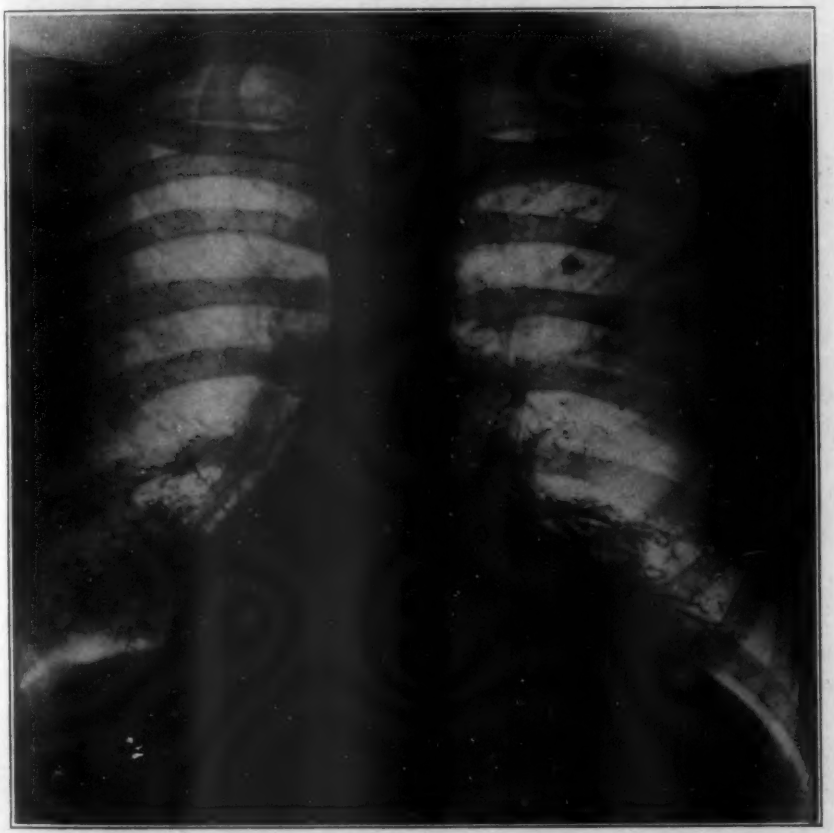

Fig. 1.—Normal distribution in patient sitting upright of iodized oil, 40 per cent, injected into both lungs at the same time.

SECOND METHOD [1]

The second method can be used only by laryngologists especially trained for this work. The advantage of this method is that the operator can directly visualize the vocal cords and introduce a tube into the trachea, through which the iodized oil, 40 per cent, can be injected.

Before the injection is begun, the patient is told that he will feel a disagreeable pressure on the neck, and will probably think that he is being choked. It is necessary to explain to him that the procedure is harmless and absolutely free

from danger, provided he cooperates perfectly. He must be perfectly relaxed, and have confidence in the operator. The pharynx and larynx are anesthetized with 20 per cent cocaine solution. The patient may have been placed in twilight sleep previously. He is then placed on his back with his head elevated, and slight extension is made at the occipito-atloid joint by the left hand of the first assistant. The bite-block is placed on the assistant's right thumb and inserted into the left angle of the patient's open mouth. Complete description of the methods of direct laryngoscopy will be found in Jackson's book.[1] With the laryngoscope in place, a catheter is introduced into the bronchus, and from 20 to 30 cc. of oil is introduced. The laryngoscope is removed, the patient is placed on the side that is diseased and the roentgenogram is taken. This method is not applicable to children or to patients who have dyspnea.

THIRD, OR BRONCHOSCOPIC, METHOD

The third method, while more exact in locating diseased areas under direct vision, requires too great skill for general adoption. The iodized oil, 40 per cent, is warmed and injected through the bronchoscope, the bronchoscope is then withdrawn, and the patient remains in the position in which the examiner desires to place most of the iodized oil.

Jackson and his co-workers have used bronchoscopic methods for lung mapping, using a finely powdered bismuth subcarbonate. The roentgenograms taken with this substance are not quite as distinct as the ones now obtained with the iodized oil, 40 per cent. I have had a patient who has received a mixture of bismuth in oil, which later acted as a foreign body in the lungs, with a resulting obstruction to drainage. This patient had a bronchiectasis in the lower part of the right lung for which he had been treated by thoracoplasty. This did not produce the desired result, and it became necessary to perform a partial pneumectomy. The bismuth in oil obstructed the drainage of certain areas of the lung.

I do feel, however, that when it is necessary to subject a patient to bronchoscopy for the usual indications, it is advisable to use iodized oil, 40 per cent, in this way.

FOURTH METHOD[2]

The fourth method is the intratracheal introduction of the oil by indirect illumination of the larynx. This method has been used in many patients, and has been found successful. The method used is to give the patient one-fourth grain of morphine combined with $\frac{1}{150}$ grain of atrophine sulphate. The patient is then brought to the roentgenologic department and placed in the upright position. The tongue is pulled out as far as possible by the patient or an assistant. The larynx is then thoroughly anesthetized with a 20 per cent solution of cocaine combined with 1:1,000 solution of epinephrine hydrochloride. The cocaine solution and the epinephrine hydrochloride should be in the proportion 1:2. The application of the solution should be made every five minutes until the operator can touch the vocal cords without producing a cough.

A tracheal catheter connected with a syringe containing 3 per cent solution of procaine hydrochloride is introduced between the vocal cords. Five cubic centimeters of this solution is introduced into the trachea and bronchi. One must

wait five minutes or more until the cough reflex is entirely abolished. If this does not result, it is useless to attempt the introduction of the oil as the oil will immediately be coughed out and will probably be swallowed.

The oil should be slightly warmed before it is used, as the operator will find it difficult to force the substance through the tracheal catheter.

Fig. 2.—Patient O. G., March 25, 1926, after thoracoplasty for tuberculosis; the bronchial tree is not visible.

When the patient is ready for the introduction of the tracheal catheter, he may be in a sitting position. Under the indirect illumination of the pharynx and larynx, the tracheal catheter or even an ordinary urethral catheter is introduced between the cords into the trachea. The warm oil is now injected through the catheter into the lung, and the patient immediately placed in the position that the examiner wishes to outline. That is, if the right lower lobe is the diseased

part, the patient is placed lying on the right side; if the middle or upper lobe is diseased, it is best to lay the patient flat, and the head may be lowered slightly to map out the upper lobe better. The left lung is outlined by reversing these directions. It is possible to outline one lung at a time in this way. The roentgenograms must be taken as quickly as possible after the introduction of the oil.

If the patient will turn from one side to the other the oil will flow by its own weight into the contralateral lung. In roentgenograms that seem to show bilateral bronchiectasis, this may be interpreted merely as an overflow of the pus from the more diseased lung.

FIFTH METHOD [4]

The fifth is the simple method which consists in the injection into the pharynx of from 20 to 30 cc. of iodized oil, 40 per cent, in the following manner: The patient opens the mouth widely, the tongue is pulled far out of the mouth and the straight cannula, which is attached to an ordinary syringe filled with the oil, is placed horizontally at the region of the base of the tongue. The patient is then requested to take a deep inspiration, during which the oil is injected. Following the injection of the oil, eight or ten successive deep inspirations are then advised, the tongue being forcibly held out and the patient requested not to swallow.

In this clinic this method has been used in many cases with good results. If the patient has a more or less naturally anesthetic pharynx, the procedure is even easier. The plethoric type of person lends himself well to this. It may be tried in patients in whom mechanical irritation of the nasopharynx is contraindicated. It is not possible to inject as much oil with this method as with those in which complete anesthesia of the pharynx is used, but good roentgenograms are obtained in most cases.

The patient will cough up most of the oil within fifteen or twenty minutes, but the remaining opacities may be observed for months afterward. Excellent results have been obtained with this method, with little discomfort to the patient. Children do not lend themselves well to this procedure, and for them the first method is recommended.

COMMENT

The value of bonchography lies in the definite mapping out of lung structure, either normal or altered by pathologic conditions. It requires considerable experience to be able to interpret these shadows, especially with so dense or so opaque a substance. In view of the fact that the lung fields may extend in an anterior and a posterior direction from 6 to 12 inches (15 to 30 cm.), one can readily understand how superimposing shadows will complicate the roentgenogram, but the true interpretation will be made in conjunction with the physical signs and history. Many

4. Lian, C.; Darbois, and Navarre, P.: Non-penetration dans la trachee des injections dites intra-tracheales faites par un procede simplifie, Bull. et mém. Soc. méd. d. hôp. de Paris **46**:470 (March 17) 1922.

Fig. 3.—Patient O. G., May 20, 1926, after the injection of iodized oil, 40 per cent, into the left lung; the bronchi are collapsed and no finer lung markings are visible.

dense shadows in the roentgenogram may be tumor masses, collapsed lung tissue or cavities filled with secretion. The opacity of the iodized oil, 40 per cent, when introduced into the lungs of these patients will often give startling pictures of pathologic conditions that were not suspected.

The oil can be used in fistulous tracts to map out chronic empyema cavities and also bronchial fistulas, and when introduced in this way it rarely excites a cough. This substance has helped to show abscessed cavities that were connected with the empyema cavities through a bronchial fistula.

In pneumothorax cases, and especially in bronchiectatic cases, iodized oil, 40 per cent, shows well the collapsed bronchi.

Jacobaeus,[5] in a recent article, described how the iodized oil, 40 per cent, in pneumothorax cases has shown that bronchial tubes were seen in adhesions extending to the chest wall. One can easily see how it could be possible to sever lung tissue with the cautery in Jacobaeus' method and produce empyema and probably death.

To summarize the value of bronchography, it is of great benefit, in combination with careful physical examination, to those who have had considerable experience with suppurative lung conditions. It should not be used in any case in which simpler methods can be used. It shows excellently the bronchial tree with abnormalities present, and when properly used it is harmless.

The first method is recommended for children and the fourth and fifth methods for adults, and the second and third methods when bronchoscopy is performed for other purposes. The fifth method should be tried in adults before attempting the more complicated ones. If unsuccessful, then the fourth is the method of choice.

Recently, Iglauer [6] devised an intubation tube which prevents regurgitation of the oil. While this method has much to commend it, one should use means with as little instrumentation as possible to obtain the desired roentgenogram.

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5. Jacobaeus, H. C.; On the Cauterization of Apex Adhesions and the Importance of Bronchography in Pneumothorax Treatment of Tuberculosis, Acta Tuberc. Scandinav. **1**:1 (Jan.) 1925.

6. Iglauer, Samuel: Use of Injected Iodized Oil in Roentgen-Ray Diagnosis of Laryngeal, Tracheal and Bronchopulmonary Conditions, J. A. M. A. **86**:1879 (June 19) 1926.

TECHNIC OF BRONCHOSCOPIC INTRODUCTION OF BISMUTH SUBCARBONATE AND IODIZED OIL, 40 PER CENT, FOR PNEUMONOGRAPHY

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PHILADELPHIA

The introduction of the radiopaque substances, bismuth subcarbonate and iodized oil, 40 per cent, into the lung for pneumonography has been found to be harmless when limited quantities are used. The substances themselves are readily coughed out, and during their sojourn in the lung have a medicinal value (fig. 6).

The bronchoscopic method of introduction gives a direct examination of the trachea and of the main bronchi of each lobe of the lung. In addition to the diagnostic value, the bronchoscopic method permits of the removal of obstructing secretions and granulations, and when an organic stenosis of the bronchus exists, it allows of the introduction of the substance by sight through the stenosis into the portion of lung distal to the narrowed bronchus. By this method the substance can be accurately placed in any desired portion of the lung and a positive pneumonogram obtained with the minimum quantity of opaque substance.

Bismuth subcarbonate, when insufflated bronchoscopically after thorough aspiration of secretions, will outline satisfactorily the tracheal and bronchial walls and bronchiectatic cavities of the larger bronchi. Iodized oil, 40 per cent, is most satisfactory in the periphery of the lung and where the abscess cavity communicates with the smaller bronchi. The cavity should be aspirated as free of pus as possible because, although iodized oil, 40 per cent, will displace air in the cavity, it will not so easily displace pus that fills the cavity completely. After aspiration iodized oil, 40 per cent, should be introduced through a flexible tipped tube into the larger tributary bronchi and be allowed to flow into the abscess cavity by gravity, the patient being placed in the proper position to accomplish this.

TECHNIC

The technic is that of bronchoscopy, with the addition of the introduction of the opaque substances through the bronchoscope. The bronchoscopic technic is as follows: The patient is prepared by withholding all food for six hours. One hour before operation, morphine sulphate, one-fourth grain, and atropine sulphate, 1/150 grain, are given to adults. The patient is brought to the operating room on a litter. Two applications of 10 per cent cocaine solution are made at five minute intervals to each pyriform sinus. The patient is then placed on the table in the dorsal recumbent position and the bronchoscope introduced according to the Jackson technic. In children under 12 years of age a proportionate dose of morphine and atropine is given, but no local anesthetic is used. Cocaine

is never used in children. A swab of 20 per cent cocaine solution is carried through the larynx, using the direct laryngoscope prior to the introduction of the bronchoscope in adults. After the introduction of the bronchoscope the secretions are thoroughly aspirated and a 20 per cent cocaine solution is applied by means of swabs to the trachea and bronchi, particularly to the portion of lung that it is desired to examine. The excess of cocaine solution is aspirated.

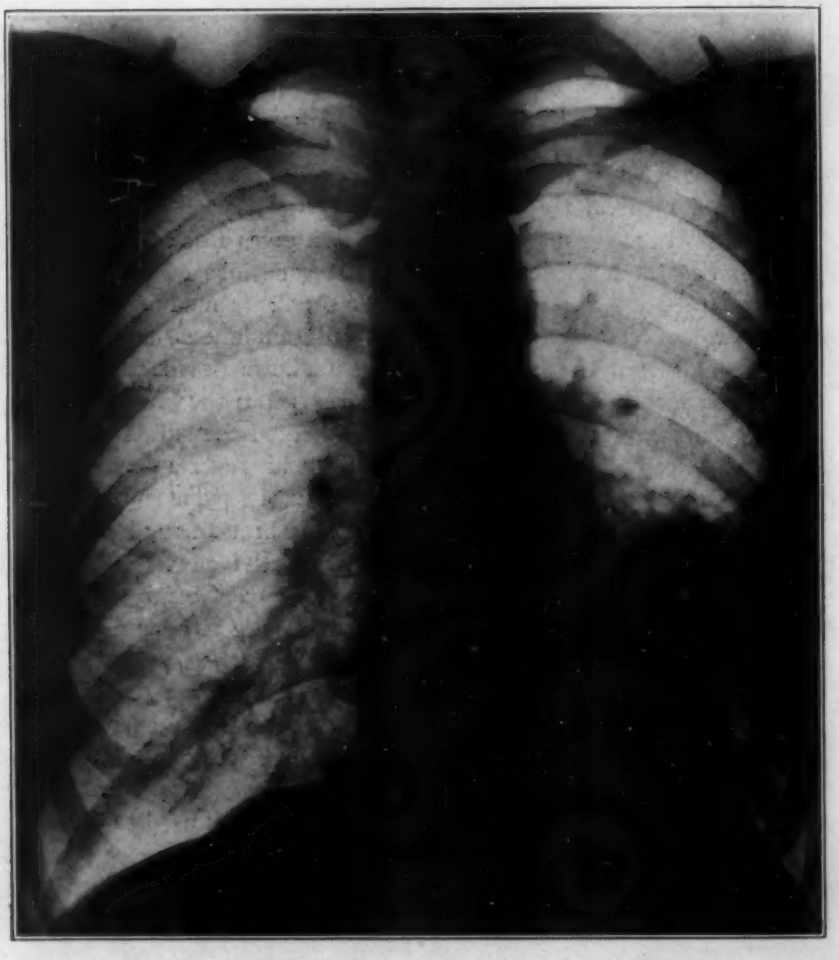

Fig. 1.—A patient, aged 24, with abscess of the left lung; there is an opaque area of uniform density in the left lower lobe.

In children aspiration through the bronchoscope is carried out without the application of local anesthesia. If bismuth subcarbonate is to be used, it is insufflated into the area desired, and the patient is sent to the roentgenologist and should not cough until after the roentgen-ray examination. If iodized oil, 40 per cent, is used after the insertion of the bronchoscope and aspiration of secretions and anesthetizing with cocaine, the portion of the lung that it is desired to examine is placed at the lowest level by raising or lowering the head

of the table and by turning the patient on the side to be examined. The oil is then injected through a flexible tipped instillation tube. The tube is withdrawn, and the patient's position is maintained after the withdrawal of the bronchoscope while the patient is sent to the roentgen-ray room on a litter. The injection may be made on the fluoroscopic table after the instillation tube is introduced by sight. This assures correct localization. The roentgenograms can be made, of course, on the same table, if the apparatus will permit it. In the introduction of iodized oil, 40 per cent, it is important that it be placed in the larger bronchi and allowed to go into the periphery of the lung by gravity.

Fig. 2.—Same patient as shown in figure 1. A plug of inspissated secretion was removed from the posterior division of the bronchus of the left lower lobe bronchoscopically. The roentgenogram, made the day following the bronchoscopic aspiration, shows a fluid level in the area that was uniformly dense before aspiration, indicating that there had been some reaccumulation of fluid in the abscess.

In a number of patients I have found blocking of the bronchi by granulations, organic stenosis or inspissated secretions so extensive that the opaque substance could not be introduced without mechanical removal of the obstruction by means of forceps or dilatation. I report two illustrative cases.

REPORT OF CASES

CASE 1.—The posterior division of the left lower lobe bronchus was completely blocked by a plug of inspissated secretion. It was necessary to remove the plug with the forceps before the bronchus tributary to the diseased area of lung could be entered. The patient, a man, aged 24, who gave no previous history of pulmonary disease, developed pneumonia. He was ill for a period of

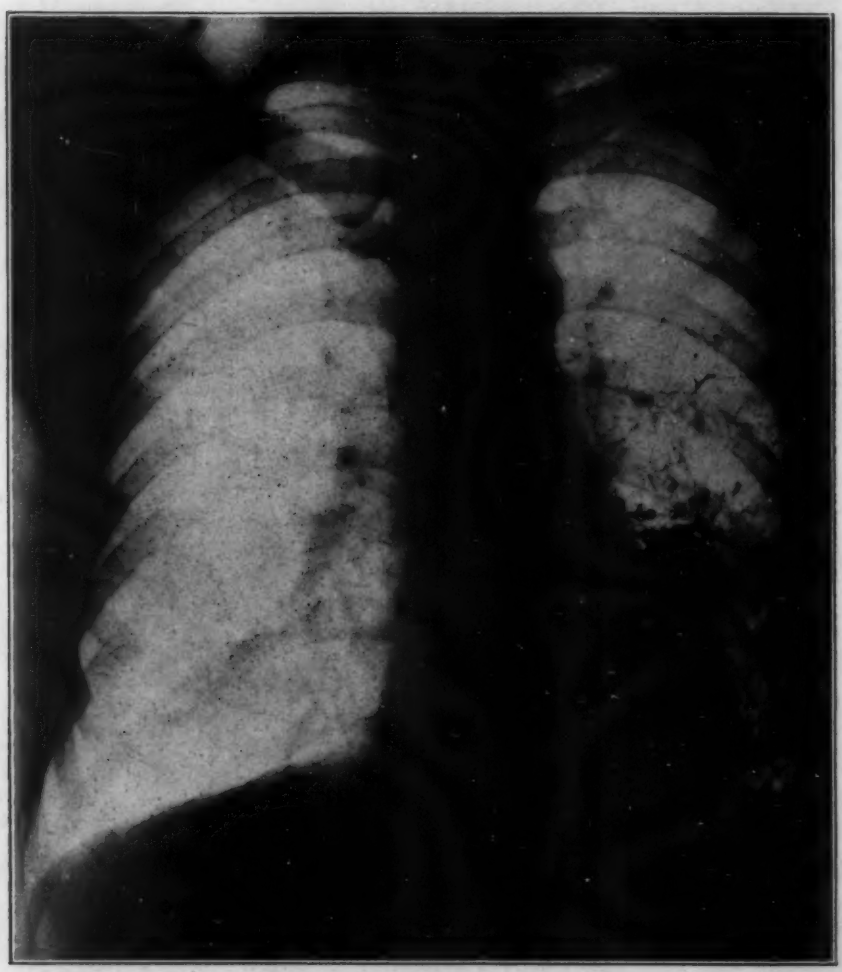

Fig. 3.—Same patient as shown in figure 1 after bronchoscopic aspiration of the pus and introduction of iodized oil into the posterior division of the bronchus of the left lower lobe; the cavity with the abscess is outlined by the opaque substance. The patient made a complete recovery following seven bronchoscopic treatments at weekly intervals (roentgenograms by Drs. H. K. Pancoast and E. P. Pendergrass.)

ten days, with signs and symptoms typical of lobar pneumonia. The temperature became normal by crisis; the productive cough subsided at the end of another week, and the man was discharged from the hospital. The patient's

condition did not improve as rapidly as is usual in such cases. He failed to gain strength and weight, and had a slight, unproductive cough. Examination of the chest showed evidence of a pathologic process in the left lower lobe posteriorly. The pleura was clear. There was no fever and no expectoration. Roentgen-ray examination showed a shadow of uniform density in the left lower lobe (fig. 1). The man was referred to Dr. Stengel's service at the University of Pennsylvania Hospital. The question arose as to whether the lesion in the lung was an unresolved pneumonia lesion or a tumor. Diagnostic bronchoscopy was requested, and on examination of the left lung no abnormal secretion was found in the left main bronchus, but the orifice of the posterior division of the

Fig. 4—A woman, aged 50, with compression stenosis of the left main bronchus and bronchiectasis, after the insufflation of bismuth subcarbonate bronchoscopically; there is stenosis of the left main bronchus, with dilatation of the larger bronchi in the upper and lower lobes of the left lung (roentgenogram by Dr. H. K. Pancoast).

bronchus of the left lower lobe was found completely blocked by a whitish substance that could not be removed by aspiration. It had the appearance of a foreign body. The bronchial mucosa surrounding it was inflammatory and thickened. The plug of organized secretion was removed with forceps and was found to extend about a centimeter into the bronchus. After its removal, a considerable quantity of blood stained pus was discharged into the stem bronchus, and an additional amount was aspirated from the abscess that communi-

cated with the bronchus. Roentgen-ray examination the following day showed a fluid level in the area that had previously shown a uniform density, indicating a partial reaccumulation of pus following aspiration (fig. 2).

Iodized oil, 40 per cent, was then introduced bronchoscopically, after the lung had been aspirated free of pus, and a cavity of considerable size was outlined in the posterior portion of the left lower lobe (fig. 3). Bronchoscopic treatment was continued, and the patient is now well. The lung is entirely clear.

Fig. 5.—Abscess in the posterior portion of the lower lobe of the left lung after the bronchoscopic introduction of iodized oil (roentgenogram by Dr. E. J. Bertin).

In this case, without the removal of the plug in the bronchus it would have been impossible to introduce iodized oil, 40 per cent, into the cavity.

Case 2.—A woman, aged 51, had had a tuberculous infection of the left lung two years before admission. Under the care of Dr. Lawrence Flick of Philadelphia, she had gained 35 pounds (15.9 Kg.) in weight and had been in good health until eight months before her admission, when she developed influenza with pulmonary symptoms. She had not completely recovered from this illness. Cough with profuse purulent expectoration had persisted, with irregular fever at times and toxic symptoms. Roentgen-ray examination showed

a peribronchial thickening in the region of the left hilum, and a diagnosis of bronchiectasis was made. A diagnostic bronchoscopy was requested by Drs. Isabel, Balph, Max Goepp and Margaret Butler, to whom the patient had been referred. On bronchoscopic study, I found stenosis of the left main bronchus due to a bulging outward of its internal wall. The mucosa was inflammatory, and the lumen of the bronchus appeared as a crescent-like slit on the external bronchial wall. Large amounts of pus were aspirated from the area of lung

Fig. 6.—The same patient as shown in figure 5 four months later; the opaque substance is no longer present in the lung and the evidence of abscess has disappeared. Three bronchoscopic treatments at weekly intervals had been given. The patient was symptomatically well.

distal to the stenosis. After aspiration of pus through the stenosed bronchus, the insufflation tube was introduced and the area of lung distal to the narrowed bronchus was insufflated. Bismuth subcarbonate was insufflated also in the bronchus above the stenosis and in the trachea at the bifurcation. The pneumonogram demonstrates the stenosed bronchus, as well as the dilatation of the bronchi distal to the point of stenosis (fig. 6).

Here again the blind introduction of the opaque substance would have failed to give a satisfactory pneumonogram, because it was necessary to dilate the stenosis before the bismuth subcarbonate could be

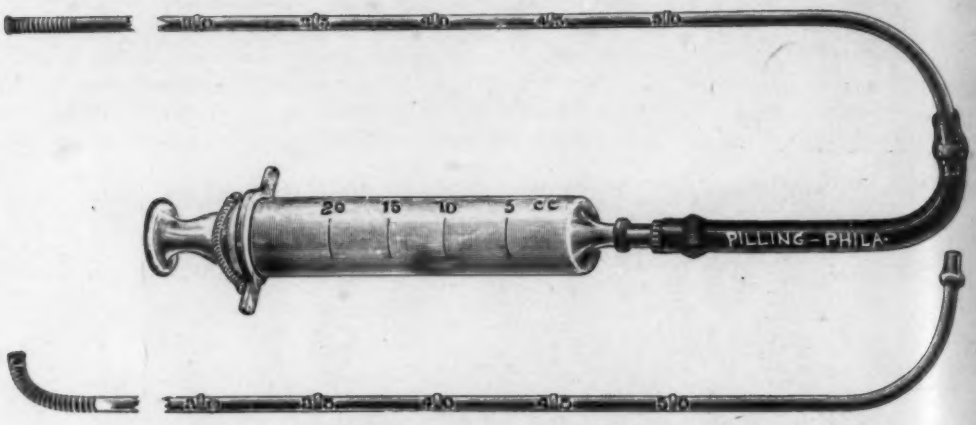

Fig. 7.—Tube set for instillation of iodized oil. The set consists of a straight flexible tipped (Lynah) tube and a curved flexible tipped (Lynah) tube to get around the corner; tubes are graduated at 5 cm. intervals to measure the depth of insertion. A rubber tube is interposed between a Luer syringe connection and the tube so that flexibility is obtained between the tube held by the bronchoscopist and the 20 cc. syringe that contains the oil for instillation.

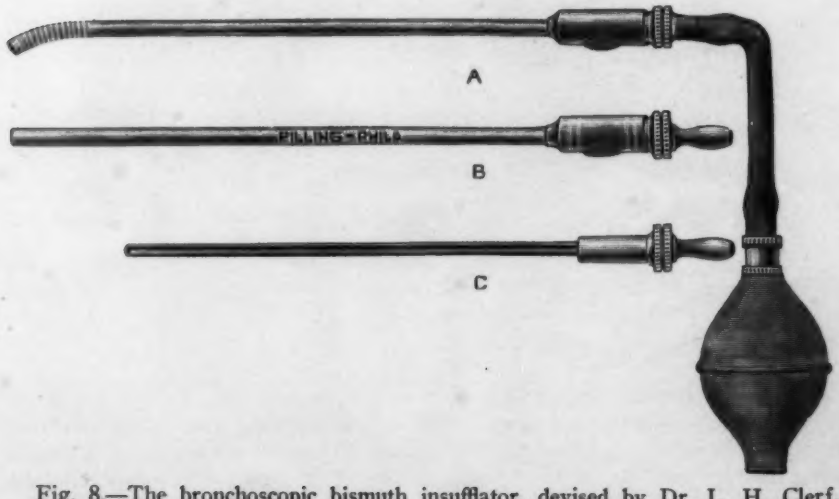

Fig. 8.—The bronchoscopic bismuth insufflator, devised by Dr. L. H. Clerf, consists of a flexible tipped tube (*A*), straight tube (*B*), gutter carrier for powder (*C*) and a hand bulb for insufflation.

introduced. The patient, who is being treated bronchoscopically, has gained weight and the stenosis is dilated sufficiently to admit free drainage of the left lung. She is now free from cought and purulent expectoration.

CONCLUSIONS

My experience leads me to conclude that (1) the bronchoscopic introduction of opaque substances into the lung for pneumonography is safer for the patient and more accurate in its localization than introduction by blind methods; (2) bismuth subcarbonate insufflation as originated by Jackson has given the best results in outlining the trachea and larger bronchi and in bronchiectatic dilatation in the larger bronchi; (3) iodized oil, 40 per cent, is best in abscess cavities and in the periphery of the lung, and (4) the most accurate pneumonogram is obtained by the bronchoscopic introduction of the opaque substance on the fluoroscopic table. The entrance of the opaque substance is observed fluoroscopically, and the plates made without transfer of the patient to another table. These considerations justify the choice of the bronchoscopic method of introduction of radiopaque substances for pneumonography, aside from the great diagnostic value of the study of local conditions afforded by direct vision through the bronchoscope preliminary to pneumonography.

PNEUMONOGRAPHY WITH IODIZED OIL, 40 PER CENT, BY THE BRONCHOSCOPIC METHOD

THE BRONCHIAL TREE, WITH OBSERVATIONS MADE FROM ONE HUNDRED INJECTIONS *

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Accurate anatomic studies of the bronchial tree, the result of investigations by the various methods of injection in postmortem specimens, were made many years ago. These methods had many disadvantages. In order to be successful, they usually had to be carried out with a fusible metal. The resulting casts of the bronchial tree were necessarily incomplete. It was impossible to control the rate of injection-flow of this not easily diffusable metal. The postmortem changes in the tissue, the obstruction from accumulated respiratory secretion, as well as the inability to maintain a uniform pressure, were some of the factors that produced what must be considered as an imperfect representation of the bronchial tree. For, although the relationship to the heart and great vessels was in many instances demonstrated, an outline of the pulmonary parenchyma and bony thorax was found to be lacking. Naturally, such studies in the living subject made with a readily injectible and easily diffusible substance offer much greater opportunities for studying and understanding both normal relationships and pathologic conditions.

In this connection, however, it is well to appreciate that even in injections made in the living, there are many factors which may influence or alter the resulting picture. These will be mentioned in the course of the article, as these factors must be taken into account in interpreting the roentgenograms of the injections.

The advantages that iodized oil, 40 per cent, has over the other agents that have of late been employed to outline the bronchial tree have been considered elsewhere.[1] Suffice it to say, that in contrasting past and present methods, one but emphasizes the fact that various methods seek to achieve the same results by different procedures.

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* From the bronchoscopic and surgical departments of the Royal Victoria Hospital.

1. Ballon, D. H.: The Injection of Lipiodol as an Aid in the X-Ray Diagnosis of Bronchopulmonary Lesions Including Tuberculosis, Preliminary Report, Canad. M. A. J. **15**:995-999 (Oct.) 1925.

This report is an accumulation of facts, the results of observations following injections and dissections. Only those observations which may serve as a clinical aid are recorded.

METHODS

In our investigations the bronchial tree in the living was injected with iodized oil, 40 per cent, by the bronchoscopic method.

Dissections in fresh specimens were carried out under water. Sodium iodide, 12 per cent, as well as iodized oil, 40 per cent, was used to inject the bronchial tree in postmortem specimens, but both were found to give poor results. The blood was injected with barium sulphate in gelatin after Gross'[2] method, and stereoscopic roentgenograms were taken. The bronchial tree was then injected with paraffin and its relationship to the circulation studied.

FUNCTIONS AND CHARACTERISTICS OF THE BRONCHIAL TREE

Functions.—The bronchial tree, in addition to its main functions, acts as a supporting substance to the alveolar structure. Its various fixed and movable points are important factors in the performance of the various respiratory movements. In addition to respiratory movement, the bronchial system has also as its function not only the admittance of gases, but also the discharge of fluids an dmucus. Therefore, one must also consider the normal contractility of the bronchus as a factor in expelling secretions and in the performance of respiration. This has been admirably looked after in that the system consists of central tubes of large diameter which receive short tributaries. The central tube is larger in a long, thin chest, while in a thick chest it is shorter and wider, the tributaries being longer.

General Considerations.—A clinical knowledge of the many bronchial branchings does not appear necessary, although some appreciation of the more common divisions and the principles which govern these divisions is required. The position and arrangement of the larger tubes are fairly constant in man. The main bronchi are unequal, yet it would appear that they are the products of a bifurcation. Their inequality is probably due to the position of the heart. It is almost an invariable rule that of two diverging bronchi, the smaller one diverges most from the position of the parent tube; this also holds good for the tracheal bifurcation, the left product of which is more oblique as well as smaller than the right. It has been proved by calculation by Ewart[3] that the lungs

2. Gross, Louis: The Blood Supply to the Heart, New York, Paul B. Hoeber, 1921.

3. Ewart, William: The Bronchi and Pulmonary Blood Vessels, London, Baillière, 1889.

of infants contain the same elements as those of the adult, their size only being different. The subsequent growth would appear to be dependent on an increase in the size of the alveoli without any addition to their number.

The roentgenographic appearance of the normal bronchial tree after the injection of iodized oil, 40 per cent, at various age periods likewise appears to be constant.

The larger tubes possess only as much cartilage as will ensure their patency, and are not in the ordinary sense rigid tubes. The smaller bronchial tubes are totally deficient in cartilage and receive instead of

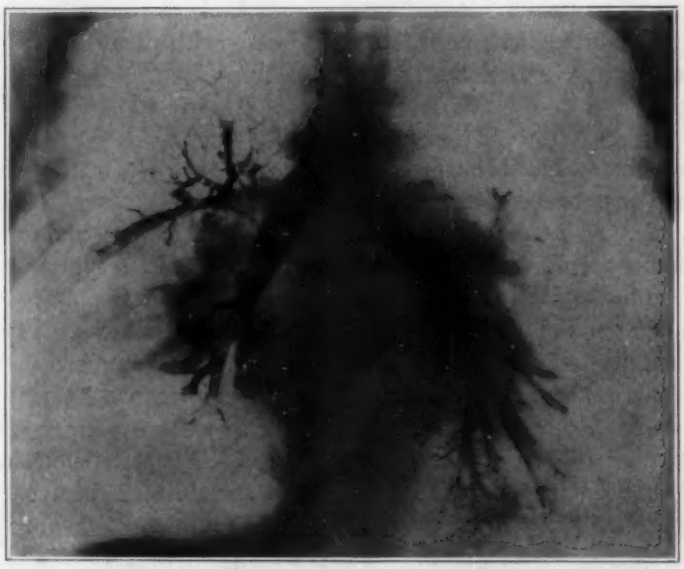

Fig. 1 (case 1).—Centrally placed trachea with long main stem bronchus and rather wide tributaries in a person with a long thick chest; 20 cc. of iodized oil had been injected. The underlying condition is an abscess of the lung in the right lower lobe; the abscess cavity is of the narrow neck type so that it has failed to fill; the iodized oil has reached the alveoli at the base of the left lung (roentgenograms by Dr. A. H. Pirie).

give support. They are thus frequently the site of disease. Of their elastic and connective tissue no mention need here be made.

The trachea lies normally slightly nearer the right upper lobe than the left and nearest the right upper lobe at its bifurcation (fig. 1). Bifurcation usually has been stated as taking place at the level of the superior border of the fifth thoracic vertebra. Injections have shown that this may vary frequently, even in the normal subject. The left bronchus is more oblique and smaller than the right, which is short and wide, and passes down as a direct continuation of the trachea. The

left bronchus, nearly twice as long as its fellow, passes under the aortic arch taking a decided curve as it descends, is crossed from above and behind by the vena azygos, and lies at first above and subsequently behind the right pulmonary artery. The left bronchus then crosses over the front of the gullet and the arch of the descending aorta, then turns backward and to the left.

The main bronchi may be subdivided into three large groups, which need no further discussion: (1) an extrapulmonary portion, (2) a

Fig. 2 (case 2).—Injection of the pulmonary artery with barium sulphate in gelatin in a normal person, aged 35; the similarity of the course of the pulmonary artery with that of the bronchial tree should be noted.

nonbranched intrapulmonary portion and (3) a branched intrapulmonary portion.

Surface Markings for Lobes.—Ordinary surface markings may suffice to mark off the lobes in the normal subject. In reviewing a series of 100 injections, we find that just as the level of the bifurcation of the trachea varies, so may the main stem bronchi branch off not only at varying levels, but they may also follow an atypical course. In this

connection, it is well to remember that the position of the patient during the performance of an injection should be considered before injection as well as after injection; for when injection is carried out with the patient lying on his back, the posterior half only may inject; so, too, with the patient in the sitting position, the anterior half may be more readily filled. Lateral views will help to show this.

Relation of the Circulation to the Bronchial Tree.—The branches of the pulmonary artery follow closely the course of the bronchial tree, dividing more frequently, however, in their remote ramifications (fig. 2). Pulmonary veins accompany the bronchi and arterial branches for but short distances. They deviate in direction from them frequently. They are never parallel to the bronchial tree, which they cross repeatedly. The arterial system may be said to be a fairly close reduplication of the bronchial tree. The artery and the bronchus enter the lung from above, the vein approaches it from below. Therefore, if we but consider the many branchings of the bronchial tree, the manner in which the circulation both follows it and crosses it, we cannot but feel that ordinary roentgen ray has a difficult task to demonstrate anything but broad markings of the normal bronchial tree. The nonbranched portion and those branches which extend posteriorly from the hilum to the base are the more common branches to show up.

Of the lymphatics, we may state that on observing the disappearance of iodized oil from the lung, some of it appears to go to the glands at the hilum of the lung, where it may persist for a considerable period of time, presenting the appearance of a calcified gland.

Abnormalities of the Bronchial Tree.—Injections have shown that variation of the level at which division of the trachea takes place normally is not rare. Variation is frequent in disease, particularly in those conditions in which there is marked fibrosis or pressure effects, as in chronic fibroid phthisis, disease of the mediastinum or pleura, or in cases of bronchiectasis in which peribronchial induration has produced much distortion of the bronchial tree and altered the position of the movable points of the main bronchi. One might expect, and injections verify the belief, that in cases in which the diaphragm is raised and adherent, the pleura thickened and the heart displaced, the bronchial tree will often be redundant, particularly in its main stems. So, too, in chronic fibroid disease it does not seem unlikely that during the process of fibrosis there should result a distortion of the bronchial tree. For contracted ribs and scarred apex, as well as the altered position of an adherent and partially immobilized diaphragm, must with the progress of time appreciably alter the contour and position of a dilatation or cavity, particularly of the bronchiectatic type. Is this nature's attempt at rest? Is one also to feel that in a person whose lung shows much fibrosis, and who has been ill for a long time, the benefits to be obtained

from further methods of collapse must often of necessity be of questionable value? Only observations made before and after injection will reveal what surgical methods have to offer in these many and varied types of lesions before the undertaking of treatment .

It becomes obvious that stenosis or compressions of bronchi prevent the filling up of the corresponding area when injected. The more common stenoses which affect the nonbranched intrapulmonary portion of the bronchial tree are usually inflammatory in origin although they are not infrequently due to neoplasm.[4] Behind these stenoses there may be an associated lesion, such as bronchiectasis or abscess. It has recently been pointed out by one of us,[5] in a review of ninety-four cases of abscess of the lung, that where there are open bronchi communicating with an external wound, a previously stenosed bronchus may become a dilated one, while in the process of repair further bronchial dilatations may develop and persist.

The branched pulmonary portion of the bronchial tree may likewise be affected by acute diseases of the pleura and lungs. Typical pneumonia, which terminates in chronic induration, may lead to thickenings and adhesions about these bronchi.

The terminal bronchioles are so intimately associated with the alveoli that lesions of the latter are certain to affect the former. Bronchial tubes do not anastamose; true dilatations, therefore, cannot be due to fusions. The T shaped branchings may, however, lead to culdesac formation, particularly in the lower lobe, which is the common site of bronchiectasis in children. These sacculations have been seen to reach the size of a hen's egg.

STUDIES OF RESPIRATORY MOVEMENTS

In the first studies of respiratory movements by one of us,[6] inspiration and expiration were registered on separate roentgenograms. Later, a double exposure was made on the same film, during deep inspiration and full expiration. A double shadow is thus cast, in which the shadow cast during inspiration is larger than that during expiration. In this way, one can compare the changes occurring in the bronchi and bronchioles during respiration. This method may also be employed with

4. Ballon, D. H.: Primary Carcinoma of the Bronchus with Abscess of the Lung, to be published.

5. Ballon, H. C.: The Value of Lipiodol in the Diagnosis and Treatment of Abscess of the Lung, to be published.

6. Ballon, D. H.: Lipiodol in the Diagnosis of Bronchopulmonary Lesions by the Bronchoscopic Method: Report of Fifty Cases, Arch. Otolaryng. **3**:403-422 (May) 1926.

advantage in empyema with bronchial fistula in determining the amount of expansion of the lungs and the degree of obliteration of the empyema cavity.

At the present time, both methods are being employed, roentgenograms being taken in the anteroposterior position, lying and sitting, and in the lateral prone and standing positions. During inspiration, a general expansion of bronchi and bronchioles begins near the hilum and spreads in all directions. The greatest expansion is downward, at and near the hilum, less outward about the midlung, and least upward at the apex. Near the diaphragm the respiratory movements in the

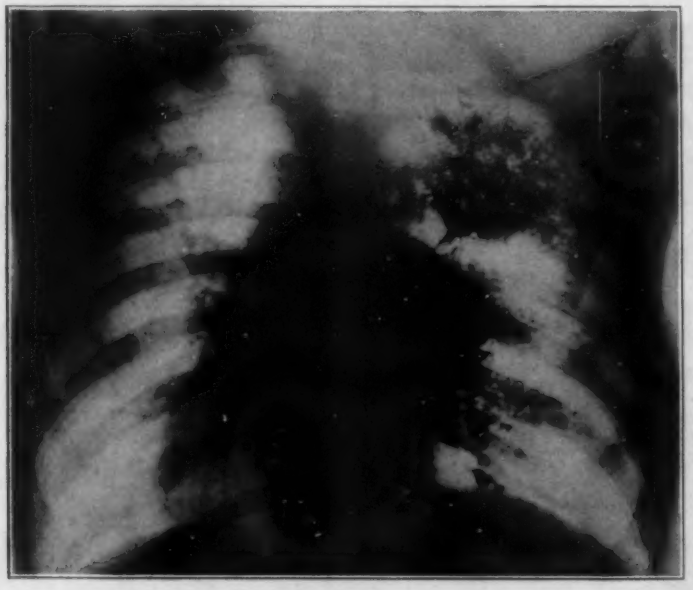

Fig. 3 (case 3).—Respiratory movements in bronchiectasis after the injection of 20 cc. of iodized oil: a double exposure taken on one film during deep inspiration and full expiration, with the patient in the dorsal decubitus position. The shadow cast during inspiration is larger than that during expiration. The rib movements and the excursion of the diaphragm should be noted.

bronchioles are upward and downward, with excursions of about half an inch (1.2 cm.). As the middle of the lung is approached, the movement is more or less horizontal. Observations on the lung parenchyma are less definite than in the bronchioles, owing to the diffuse shadow cast by the parenchyma. The darker shadows observed in some areas of the lung are due to superimposed iodized oil. During inspiration the iodized oil separates; during expiration it is jammed together and is therefore cloudy (fig. 3).

Rib movement normally is equal and is about one-fourth to three-fourths inch. The movement of the clavicle is more than 1 inch

(2.5 cm.), and seems to be greater in the direction of the apexes than toward the base. Is this to be interpreted as a movement which is purely an expression of accessory muscles of respiration? All movement converges to the hilum, lateral movement at the hilum being about 1 inch. The outer movement is inspiration and the inner movement expiration; that is, the movement from periphery to midlung is that of expiration, while the reverse is that of inspiration. The heart movement may also be seen in some of the pictures. It is for that reason that inspiration and expiration should be taken rapidly, one following on the other.

The excursion of the diaphragm should be observed, and compared with lung movements at various levels. The movement of the diaphragm and bifurcation, which is usually upward and downward, also should be noted; likewise, variations in the appearance of the arch of the diaphragm, which is larger during inspiration than it is during expiration.

Studies in respiration are incomplete unless the ordinary examination of the chest, the bronchoscopic roentgenogram and the fluoroscopic appearance are recorded. The following brief paragraph illustrates some of the observations that can be recorded during a bronschoscopic examination that includes an injection of iodized oil. They will serve in many instances not only as an aid to treatment but as a definite help in estimating the prognosis.

OBSERVATIONS TO BE MADE WHILE PREPARING THE PATIENT

While anesthetizing the larynx one may observe the nature and amount of sputum that is coughed up. This may be compared with what is brought up by bronchoscopic aspiration and posture. The rigidity or flexibility of the bronchial tubes as well as the respiratory movements at the carina should be noted, and cultures should be taken. A bronchoscopic diagnosis should then be made. The general condition of the patient up to this point serves as an index as to the amount of iodized oil that should be injected, and the amount of time that can be expended during the balance of the examination. The interval that elapses following the taking of the roentgenograms as well as the activity of the cough reflex, and the amount of sputum raised during the taking of roentgenograms, should then be recorded.

The roentgenograms should then be studied with the roentgenologist, as only thus can complete report be made. Roentgenograms taken with the Bucky diaphragm are usually much clearer and usually give greater detail. Differences should be noted; one should likewise not be satisfied with a single roentgenogram in one position. A series of roentgeno-

grams taken in varying lateral positions are often definitely different, and at times demonstrate how one can draw conclusions as to the effects of posture.

One should then sum up all information obtained, and attempt to explain signs and symptoms on the basis of observations that have been made, for only in this way can prognosis be made. Before undertaking treatment, particularly in conditions of the bronchial tree which are so often chronic and extensive, it should be made certain whether the complaints are amenable to treatment.

DISEASES OF THE BRONCHIAL TREE

Diseases of the bronchial tree may be classified as those that act as a hindrance to respiration or those that affect the lumen by forces either from within or without. They are often but expressions of abnormalities. The trachea is often the seat of inflammations which are usually secondary. Displacements and deviations of the trachea are likewise due to extratracheal mechanical factors. The rôle of the foreign body, which has been so admirably described by Jackson,[7] or tracheo-esophageal fistula, needs only to be mentioned. An enlarged thyroid gland, particularly of the substernal type, as well as intrathoracic swellings, may alter the shape of the trachea considerably, acting purely as mechanical factors. The main bronchi in their extrapulmonary and nonbranched intrapulmonary portions by virtue of their position are naturally frequently subjected to stress and strain. They may be the site of stenosis and new growth. Enlarged glands about the hilum may give expression to their existence by pressure, and as such are being recognized as an etiologic factor in the production of certain types of bronchial asthma. The branched intrapulmonary bronchi are the most frequent sites of disease, such as bronchiectasis, putrid bronchitis, bronchiolitis and bronchiolectasis.

With regard to bronchiectasis, the true congenital or atelectatic type is rarely encountered. Bronchiectasis in which the dilatations are marked and the cough and expectoration relatively slight, is so frequently encountered in children, however, that one feel that dry bronchiectatic dilatations often may be present from birth, at least for many years before they attract attention. Several cases of what the French call "forme sèche hémoptoïtaque de la dilatation des bronches" have been reported by Bezançon [8] and others. Table 1 illustrates our classification of bronchiectasis, made possible by iodized oil.

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7. Jackson, Chevalier: Chronic Nonspecific Infections of the Lungs, J. A. M. A. **87**:729-736 (Sept.) 1926.

8. Bezançon; Weil; Azoulay, and Bernard: Forme Sèche Hémoptoïque de la Dilatation des Bronches, Presse méd. **32**:157-159 (Feb. 20) 1924.

TABLE 1.—*Classification of Bronchiectasis*

A. CLINICAL

Congenital or Acquired	Unilobar or Multilobar
Acute or Chronic	Unibronchial or Multibronchial
Unilateral or Bilateral	Bronchiolar

Roentgenologic types based on injection of iodized oil, 40%

Grape | Clubbing | Cylindric | Saccular | Bead Formation

B. PATHOLOGIC

1. Bronchiectasis, chronic infective
2. Bronchiectasis, secondary, due to stenosis, new growth pulmonary fibrosis, etc.
3. Bronchiectasis, dry with hemoptysis
4. Bronchiectatic abscess, acute
5. Bronchiectatic abscess, chronic with bronchiectasis
6. Bronchiectasis, chronic, associated with abscess of the lung
7. Bronchiectasis, tuberculous: A, diffuse; B, local

(1) The grape formation is shown in figure 4; (2) clubbing, in figure 5; (3) the cylindric in figure 6; (4) the saccular in figure 7, and (5) the bead formation in figure 8. *A*, the diffuse type is seen in figure 9, and *B*, the local type in figure 10.

The value of such a classification in the diagnosis and treatment of bronchiectasis has been considered by us elsewhere.[9]

As bronchiectasis is so frequently associated with abscess of the lung, the following classification of abscess of the lung, which has already been published, will be again here noted.

TABLE 2.—*Classification of Abscess of the Lung*

SOLITARY

a. With fluid level, acute or chronic
   This type of abscess is demonstrable by ordinary roentgen ray
b. Large bronchiectatic abscess, acute or chronic
   This type of abscess may be aspirated and will inject with iodized oil, 40 per cent; often it is bilateral, and at times is associated with some other phase of bronchiectasis
c. Associated with bronchiectasis, chronic
   This is the narrow neck type in which expectoration is only overflow; it shows no fluid level, and on injection the abscess area casts no shadow

MULTIPLE—Lung abscesses, chronic

SECONDARY—Those due to tumor and foreign body

TUBERCULOUS

This type may be associated with bronchiectasis, acute or chronic
Metastatic lung abscesses and cyst degeneration are not considered in this classification

9. Ballon, D. H., and Ballon, H. C.: The Diagnosis of Bronchiectasis: Further Studies on the Value of Lipiodol by the Bronchoscopic Method, to be published.

Fig. 4 (case 4).—Bronchiectasis in the right lower lobe, showing the grape formation, after the injection of 10 cc. of iodized oil (patient of Dr. Edward Archibald).

Fig. 5 (case 5).—Chronic infective bronchiectasis of the unilobar multibronchial type, showing characteristic clubbing, after the injection of 20 cc. of iodized oil.

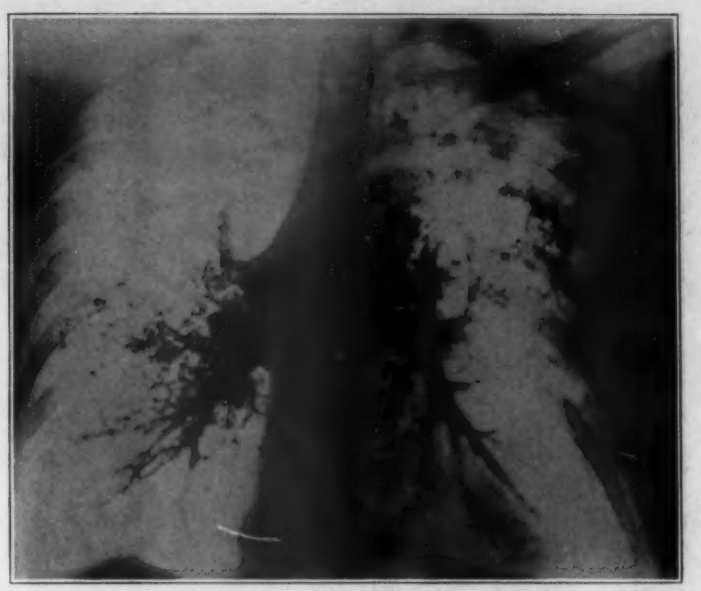

Fig. 6 (case 6).—Bronchiectasis of the cylindric type and clubbing after the injection of 40 cc. of iodized oil; the condition is bilateral. In this type there is frequenly an ectasia of the whole bronchial tree.

Fig. 7 (case 7).—Bilateral bronchiectatic abscess, with bronchiectasis of the saccular type, with which there is frequently the associated clubbing. This patient, aged 13, was referred by Dr. Roddick Byers. Twenty-five cubic centimeters of iodized oil, was injected into the bronchi, and repeated in one week without ill effects.

Fig. 8 (case 8).—Bronchiectasis of the bronchiolar type, showing bead formation, after the injection of 20 cc. of iodized oil into the right lung (patient of Dr. W. F. Hamilton).

Fig. 9 (case 9).—Tuberculous bronchiectasis of the diffuse type, resembling the fingers of a glove, after the injection of 30 cc. of iodized oil into the bronchi. This type, which extends well to the periphery, responds well to methods of compression (patient from Dr. Edward Archibald's service).

We may also mention that putrid bronchitis need not necessarily be associated with bronchiectasis. We have several instances in which the roentgenogram of the injection showed a normal appearance.

EFFECTS OF THORACOPLASTY ON THE BRONCHIAL TREE

It is interesting to observe how such factors as extrapleural thoracoplasty may affect the bronchial tree in a purely mechanical manner. Following extrapleural thoracoplasty for tuberculosis, the bronchial tree

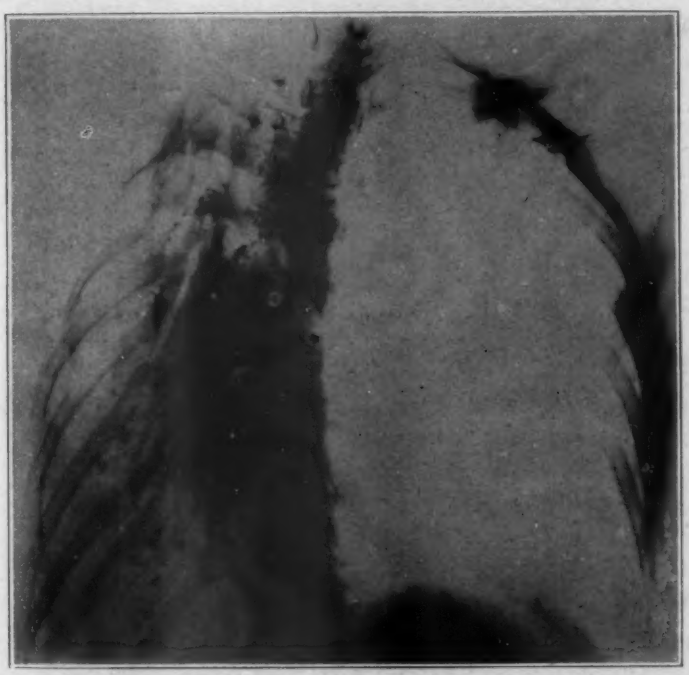

Fig. 10 (case 10).—Tuberculous bronchiectasis of the local type which had persisted following extrapleural thoracoplasty; it was responsible for persistent cough and expectoration. The first injection of 10 cc. of iodized oil was made Aug. 11, 1925.

may become a large tube with dilatations at the base, as in many instances a suitable case of pulmonary tuberculosis for thoracoplasty has an associated basal bronchiectasis.[10] The object of the operation naturally is to collapse cavities, and these are more commonly apical. If the cavity is not too close to the hilum, thoracoplasty usually accomplishes its task.

10. Archibald, Edward: X-Ray Demonstration of Pulmonary Changes in Tuberculosis by Lipiodol Injection, Canad. M. A. J. **15**:1000-1002 (Oct.) 1925.

Since iodized oil has been introduced into roentgenology, it has been noted that the treatment of the associated bronchiectasis plays no small part in the problem of the surgery of pulmonary tuberculosis.

In our classification of bronchiectasis, we feel that the fact as to whether the bronchiectasis extends well to the periphery or is purely confined to the medial and lower half of the lower lobe should be of importance in estimating the amount of compression that thoracoplasty will produce (fig. 11). In the former case, when dilatations extend to

Fig. 11 (case 10).—Tuberculous bronchiectasis following a third stage of thoracoplasty, after the injection of 25 cc. of iodized oil, Feb. 18, 1926. This roentgenogram illustrates how further compression may fail to affect this type of bronchiectasis (patient of Dr. Edward Archibald).

the periphery, methods of collapse should undoubtedly in many cases remove these factors, which have produced and caused these dilatations to persist. In the latter instance, when the dilatations are basal, the result after further collapse may not be so complete.

Iodized oil sinks only to a certain level in a bronchiectatic tube, and persists longer if respiratory movement is insufficient. Is phrenicotomy beneficial in such a case, that is, in cases in which thoracoplasty also has been performed and the type of bronchiectasis already described has persisted?

In studying roentgenograms taken following thoracoplasty, in which iodized oil has been injected, persistent cavities often present an irregular outline. The impression is that pleural adhesions possibly are preventing collapse of the cavity. For this reason more careful consideration than has been given in the past should be given to the amount of pneumothorax which has been attempted before operation, the period of time in which it has been carried out and the nature of the pleural adhesions which may be present and have persisted and rendered further collapse impossible. When these facts are compared with the size and shape of the cavity, it would appear that they should serve as a valuable aid in telling one not only how much rib to remove before a satisfactory collapse can be obtained, but also as to the area that requires the greatest amount of compression. It should also help one to determine whether anterior compression, apicolysis or other means are necessary to produce the desired change in the shape and contour of the cavity and the associated dilatations. The fact as to whether there has been fluid in the pleural cavity which has required frequent aspirations is likewise of importance, and too frequently fails to come into the estimation of prognosis.

One might perhaps ask whether the low vital capacity in many of the persons who have marked chronic cough and expectoration, who show no gross evidence of pulmonary congestion, and who are otherwise in fairly good health, is not in some instances an expression of poor pulmonary ventilation explained on the basis of diffuse fibrosis, in a lesion that is characterized by avascularity. Perhaps, too, the ideal stage at which to operate on a patient with fibroid phthisis is not being sufficiently recognized, and fibrotic changes are waited for too long. The number of suitable cases of pulmonary tuberculosis accompanied by empyema which are allowed to progress until a bronchial fistula develops before intervention is attempted is striking.

The mere fact that the heart is frequently pulled decidedly to the more affected side, and often overlies a cavity with which it is perhaps connected by a broad adhesion, must also frequently be a hindrance to a good result.

It is hoped that the foregoing digression will illustrate the fact that the proper use of such an agent as iodized oil in diseases of the thorax should in many instances enable one to treat each case individually rather than as a type case of a broad group. In chronic cases, in which the patients are poor risks and often can stand little handling, it is hoped that when the chance to use it is presented to them, they may take it. Persistent signs and symptoms will likewise be more adequately explained.

FACTORS THAT AFFECT THE FLOW AND DISTRIBUTION OF IODIZED OIL

Many factors normally affect the flow and distribution of iodized oil through the bronchial tree; the method of injection and the position of the patient have been referred to. In disease, the amount and the nature of the secretion in the tubes has likewise been noted. The bronchoscopic roentgenogram showing the caliber of the tubes during respiration and in various positions reveals well the benefits of postural treatment. Although the cough reflex helps to expel secretions from bronchiectatic tubes, the patient with bronchiectasis will often state that the only times he is able to bring up the really heavy sputum is when the carina is irritated or he becomes overheated. This sputum is usually present in the dilatations beyond the level of injection, and otherwise can often be brought up only by bronchoscopic aspiration. When iodized oil is employed by the bronchoscopic route, it should yield information that will help to increase the good results of postural drainage; it should reveal the shortcomings of present methods.

ROENTGEN-RAY REPORT ON THE BRONCHIAL TREE

The usual roentgen-ray reports on the bronchial tree are unsatisfactory and often confusing. Such reports as "calcification at the root of the tree and intensification of the bronchial tree through both lungs" are often disconcerting. A report of this nature in the presence of chronic cough and expectoration not only fails to give any information as to the site and extent of the disease, but suggests that the condition is bilateral. In the absence of a positive shadow, the patient is placed on symptomatic treatment, and is told to report to an outdoor clinic for observation; years often go by before a positive diagnosis is made. Many of these conditions are bronchiectatic, and although it is perhaps expecting too much to hope for many cures in chronic bronchiectasis, still one should be able to produce more improvement and prevent certain conditions from progressing.

The limitations of the ordinary roentgen-ray report of the bronchial tree, however, must be expected. For as we have already noted, it is normal frequently for the bronchial tree to divide, and it is so repeatedly crossed by part of the pulmonary circulation that one can hardly expect anything but a mere outline of the main stems. In diseases affecting the bronchial tree, the branches must frequently be bent. Peribronchial inflammation and adhesions must likewise affect the picture.

VALUE OF POSTURAL DRAINAGE

The value of postural nonsurgical drainage is entirely dependent on the type of lesion, its site and the nature of the underlying pathologic lesion. A narrow, partially rigid tube affected by stenosis will not

respond to mere posture, but requires something else in the way of an aid. Bronchoscopy and bronchoscopic methods often supply this want. Each case should thus be considered a law unto itself.

INTRABRONCHIAL ROUTE FOR APPLICATION OF MEDICATION

The intrabronchial route should be employed more frequently than it has been in the past for the direct application of therapeutic agents because it disseminates them by coughing. In such conditions as putrid bronchitis, when it is not associated with bronchiectasis, or in the non-sensitive asthmas, it is often of extreme value. In bronchiectatic conditions it is also of value, but it is the frequent aspiration and emptying of these dilatations that produce the best results.

CAUTIONS AS TO ABNORMAL SHADOWS AND CHOICE OF PATIENT

We cannot conclude this report on the bronchial tree, in which the value of iodized oil is obvious, without uttering a few words of caution: first, as to the interpretation of abnormal images that are not associated with signs and symptoms, and second, as to the fact that the promiscuous an abscess cavity or dilatation.

A positive shadow that is cast by an injection of iodized oil which cannot be adequately explained on the basis of a clinical history, signs and symptoms should be neglected. Our knowledge as to the interpretation of many of these shadows is still vague. Insufficient pulmonary ventilation, immobilization of the parenchyma or temporarily arrested respiratory movement may be responsible for a shadow that simulates an abscess cavity or dilatation.

No injection of iodized oil should be undertaken until a complete history and physical examination have been carried out. The person who is to give the injection should then not only observe the patient himself but also should discuss the condition of the patient with the attending physician before attempting an injection of iodized oil, and then give it only after deciding that it will be of value. Extremely ill patients should thus not receive injections of iodized oil or the results will cause the method to fall into disuse. In the case of a foreign body, not even the most ardent antispecialist would refrain from having a bronchoscopic examination made.

The use of iodized oil is of undoubted, and promises to be of further, value, if used intelligently. If special methods are used in their proper place, specialization will occupy an even more enviable position than it does at present.

SUMMARY AND CONCLUSIONS

In the living subject, the bronchial tree was injected with iodized oil, 40 per cent, by the bronchoscopic method; in postmortem specimens, it was injected with paraffin. The blood was injected with barium sulphate in gelatin, and its relation to the bronchial tree was considered. The physiology of respiration in the normal and pathologic lung was studied.

Lung abscesses were classified after studies made following the injection of iodized oil.

At various age periods, the appearance of the normal bronchial tree after the injection of iodized oil appears to be constant.

Abnormalities of the bronchial tree are frequent in chronic fibroid phthisis, diseases of the pleura and mediastinum and bronchiectasis.

Bronchial stenosis is often found to be associated with bronchiectasis or pulmonary abscess.

The branched intrapulmonary bronchi and bronchioles are the most frequent sites of bronchiectasis, putrid bronchitis, bronchiolitis and bronchiolectasis.

The bronchial tree after extrapleural thoracoplasty for tuberculosis may undergo numerous changes, and becomes a large tube associated with localized or generalized bronchiectasis at the base. When the bronchiectasis extends to the periphery, methods of collapse should give better results than when the dilatations are basal.

Iodized oil by the bronchoscopic method is an aid and a guide in the selection of suitable cases for the thoracic surgeon, and in the prognosis and treatment. It makes it possible to treat each case individually, and increases the good results obtained by postural drainage.

Ordinary roentgenograms of the bronchial tree are unsatisfactory and often confusing, owing to the fact that the bronchial tree divides frequently and is repeatedly crossed by part of the pulmonary circulation. It fails to give any information as to the site and extent of the disease.

The importance of the accurate interpretation of roentgenograms made following the injection of iodized oil must be emphasized. A positive shadow cast by an injection which cannot be adequately explained on the basis of clinical history, signs, symptoms and a bronchoscopic examination should not be considered. A typical shadow when substantiated by a clinical picture allows of no discussion.

SEPTIC CONDITIONS OF THE CHEST

ETIOLOGY AND DIFFERENTIAL DIAGNOSIS

DAVID A. STEWART, M.D.
NINETTE, MANITOBA

I am not on the program and have no prepared paper, but I have a few slides I can show and add some comments, so that, in the absence of Dr. Stuart Pritchard, the medical side of the problem may not be left altogether without a representative.

The thoracic surgeon is seldom the first, and may be even the fourth, diagnostician in these cases. The first, and usually a poor one, is the man himself. If conditions become serious, he calls the family physician, who, in turn may consult with a sanatorium physician of more specialized experience, and still later the surgeon may be called in. If any such order as this is followed, the surgeon sees the fewer patients with the most severe condition; the famaily physician a much larger, and, on the average, less troublesome, number, while perhaps most patients are allowed to develop a more or less chonic condition at home. This condition is called chronic bronchitis, asthma or "stomach cough." If the least and the greatest of these bronchopulmonary septic infections were counted, they might be called legion, for they are many. The pyorrhea cure advertisers assure us that "four out of five have it." What might be shown by a careful study of the persons with a chronic cough in any community?

One common cause of these septic conditions seems to be bad teeth and gums and badly cared for mouths. One of the commonest clinical pictures is that of cough, expectoration, debility and bad teeth. The cleaning of the mouth, with a comparatively short period of rest, will work wonders in some such cases. Impressive also are the large numbers in whom cough and expectoration, chronic and increasing, with such general symptoms as debility, and not infrequently with hemorrhage, follow acute respiratory diseases, especially of childhood. A man of 22 has coughed and expectorated since he had pertussis in his first year; others, since they had influenza months or years before; one, since he had measles at the age of 9, and many since they had pneumonia in childhood. The cough-expectoration syndrome dating back to childhood, is common; the patients will state that they have had cough as long as they can remember.

The infections following operations under general anesthesia are well known. In many of these septic infections, spirochetes and fusiform bacilli have been found, as described by Dr. David Smith of Ray Brook, N. Y. In some such cases neoarsphenamine has been adminis-

tered. So far it cannot be stated that it has benefited patients much, but the spirochetes in some of these cases have disappeared from the sputum at least temporarily.

"Chronic bronchitis" has been a convenient term under which many conditions of the respiratory tract have been described. It is time for these conditions to be defined more closely. Injection of iodized oil for outlining of the bronchial tree and bacteriologic examination will both help.

From the medical point of view, the excellent results that can be secured by rest and posture in the earlier cases of every type of septic infection is impressive. Rest may be the best treatment in these cases. Two months in bed may relieve a cough that has lasted many months or even years. Perhaps it is time to begin teaching prevention as well as cure.

Below is an outline of the points to be noted in the differential diagnosis between earlier cases of septic infection and pulmonary tuberculosis.

Comparison of Septic Infections and Pulmonary Tuberculosis

	Septic Infections	Pulmonary Tuberculosis
Lesions	Usually basal	Usually apical
Sounds	Musical rhonchi common	True râles, small, crepitant
	Coarse râles	Coarse râles chiefly in cases in which there is secondary infection
Cough	Much at early stages	Little or none at early stages
	Increased amount in late active stages	Variable at all stages
Expectoration	Profuse even in early stages	Slight or absent in early stages
	Increasingly profuse in late stages	Profuse usually only with secondary septic infection (i. e., tuberculous plus septic)
	Often bad smelling	Bad smelling, sometimes with secondary infection
Dyspnea	Usual and marked	Less usual and less marked
	Consistent with good condition	Not usual with good condition
	Can be dyspneic but not ill	Likely to be ill if dyspneic
	Related to extent of lesion chiefly	Related to toxemia chiefly
Hemoptysis	Less usual	More usual
	Blood streaked sputum more common	Less common
Pleurisy	Uncommon	Common
Other Pains in the Chest	Common, troublesome, basal, less localized	Less common; slighter; often apical; unilateral; more localized
Roentgen-Ray Signs	Variable, usually basal	Variable, usually begins at apex
	Often slight, with gross symptoms (without injection of iodized oil	Often gross, with slight symptoms
	Iodized oil, as useful as barium in abdominal diagnosis	Iodized oil, useful but not so necessary as in septic infections
Complications	Of septic type, appendicitis, mastoid, pneumonia, etc.	Of tuberculous type, tuberculosis in other organs
Course	Variable	Variable
	Chronic	Chronic
	When chronic less curable	When chronic more curable
Tuberculin	No great help in differentiation	
Examination of Sputum		A few negative reports are inconclusive, persevering examination reveals bacilli usually, if present

Septic infections and pulmonary tuberculosis are hard to differentiate; there are no invariable rules concerning this. The symptoms are the same, but they differ in their manner of occurrence. Diagnosis is made not by adding symptoms to make a total, but by grouping symptoms to make a picture. There are wide variations in the symptoms in both diseases.

VALUE OF IODIZED OIL, 40 PER CENT, IN THE DIAGNOSIS OF PULMONARY INFECTIONS

EDWARD W. ARCHIBALD, M.D.
MONTREAL

My interest in diagnosis by the use of iodized oil, 40 per cent, while of course general, has been centered in particular on its value in tuberculous cases: on the one hand, in order to show more clearly than might be possible by physical examination or the ordinary roentgen-ray examination, the pathologic condition in a lung previous to a proposed thoracoplasty; on the other hand, to show the condition in the lung which might explain a lack of complete success years after a thoracoplasty. In addition I shall report a few cases illustrative of its value to the surgeon in nontuberculous lesions.

REPORT OF CASES

CASE 1.—C. R., a man, who had had tuberculosis since 1919, with repeated pulmonary hemorrhages, had had a thoracoplasty performed two years previously but an incomplete one, the first and second and the tenth and eleventh ribs having been left intact. He had improved considerably, but for the last few months before admission to the hospital, cough and sputum had again become troublesome. The usual roentgenogram showed nothing but a dense, homogeneous shadow. One taken after an injection of iodized oil, 40 per cent, revealed marked bronchiectasis in the lower lobe, and the persistence of some cavitation in the upper lobe. A complete thoracoplasty was performed, the reformed bone and the other ribs being removed, with excellent compression and an excellent clinical effect. Such correction operations frequently are worth while. Parenthetically, it may be said that iodized oil almost always reveals the existence of a bronchiectatic condition in the lower lobe in these old tuberculous cases.

CASE 2.—Miss L. had had tuberculosis probably since 1910. In 1912, she had had fever, had been fatigued easily, and had raised a slight amount of sputum. Since then the disease had been quietly progressive, and when she consulted me there was considerable cavitation in the left upper lobe and slight disease on the right side, apparently quiescent. The roentgenogram after the injection of iodized oil revealed the large size of the cavity. After the injection of the oil, however, she had a febrile reaction with an increase in the pulse rate, which lasted a week. After the subsidence of the fever, I performed a thoracoplasty. The wound became partly infected. In spite of this, I performed the second stage, which was probably an error in judgment. She had a large cavity under the scapula, and I separated the lung extensively both from the vertebral side and anteriorly under the stumps of the ribs, in order to collapse the cavity. This was followed by an acute tuberculin intoxication, which left her extremely weak; moreover, the upper wound suppurated. It is probable that she would have survived, but about the tenth day a serious secondary hemorrhage occurred in the wound, which, in her weakened state, proved fatal in a few hours.

Had iodized oil any effect in reducing her resistance before I operated? I am inclined to feel, with Dr. Singer, that it was more likely the strain of the bronchoscopic examination which caused the reaction. In more than twelve cases of tuberculosis in which iodized oil has been injected through the bronchoscope, only three patients have shown a febrile reaction. In two this was not serious and consisted in a rise of temperature to 100 or 101 and an increase in the pulse rate, both of which disappeared in the course of four or five days; but in the third case (case 3 in this article), it continued for nearly ten days, when I considered it wise not to wait longer and performed a phrenicotomy. Immediately after the operation the patient had a further rise of tem-

Fig. 1

Fig. 2

Fig. 1 (case 1).—Before injection of iodized oil. Note homogeneous shadow and lack of detail on left side.

Fig. 2 (case 1).—After injection of iodized oil. The oil reveals extensive bronchiectasis in lower lobe, behind the heart, and it also partially fills the cavity in the upper lobe. On the right side the oil shows a normal lung.

perature and increase in pulse rate, and ultimately died of rapid activation of the process in the good lung. I feel that one must exercise more caution in using iodized oil in such cases, and I believe that I shall have to adopt Dr. Singer's simple method for the tuberculous patient, in order to avoid as much as possible the strain of the bronchoscopic examination.

Case 3.—The roentgenogram of Mrs. S. shows a homogeneous shadow, with the exception of the cavity at the top. She had been sick since 1920. She had had bronchopneumonia in 1924. A test phrenicotomy was performed. After six days she died of acute tuberculous bronchopneumonia of the good side.

Fig. 3

Fig. 4

Fig. 3 (case 4).—Note the homogeneous shadow on the left side in this old thoracoplasty case.

Fig. 4 (case 4).—The iodized oil reveals a fairly large cavity in the upper part of the lower lobe.

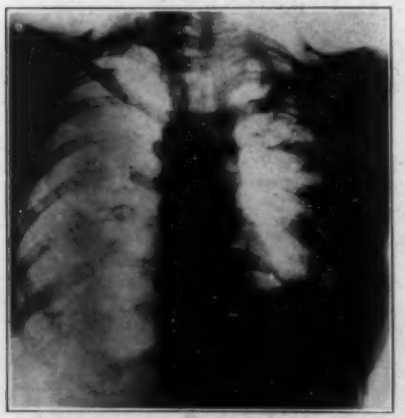

Fig. 5

Fig. 6

Fig. 5 (case 7).—Before injection of iodized oil. Case of nontuberculous inflammation of upper lobe, with distinct cavity just under scapula.

Fig. 6 (case 7).—After injection of iodized oil. Note unexpectedly enormous size of cavitation in upper lobe and slight bronchiectasis in lower lobe.

Whether the iodized oil which penetrated the less diseased side had any effect in starting the acute tuberculous process is a question. It is almost impossible to say whether it had or not, but this case suggests the necessity for caution. It is much more likely, of course, that the slightly active disease on this side was aggravated by the operation. In any case, that activation may have been assisted by the previous injection of iodized oil.

CASE 4.—Miss D. consulted me in 1922 concerning a lesion on the left side. The left lung had a large cavity at the apex. She was greatly improved by a thoracoplasty. Symptoms recurred in two years, and the cause of this recurrence was revealed only by the injection of iodized oil, which showed a new cavity in the lower lobe.

I think that iodized oil is valuable in estimating what lesions remain. By stereoscopic examination the lesion can be localized as near the hilum or near the periphery. The question is, What can be done for

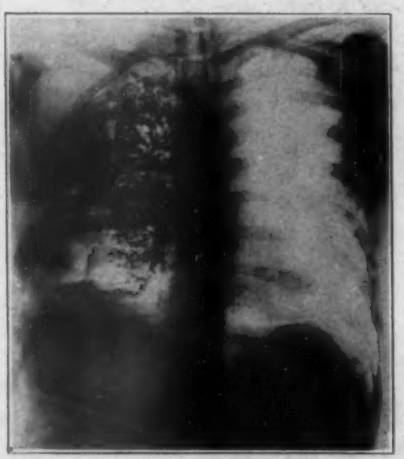

Fig. 7 (case 8).—Case of chronic empyema. After injection of iodized oil. The oil shows up the fistulous tract in the pleura and a partial filling of the empyema cavity; it also demonstrates that the underlying lung is normal.

such a lesion? Should one resect more ribs? I leave it at that; but the point is that only by means of oil injections can one get an idea of the problem to be faced.

CASE 5.—Two years ago, after a total thoracoplasty, Mrs. D. returned with an aggravation of symptoms. The cavity, which persisted, was not visible in the usual roentgenograms, but showed in the roentgenogram made after the injection of iodized oil.

CASE 6.—Mrs. McI. was a tuberculous patient with a cavity in the left upper lobe. I did not know that this was so large until after the injection of iodized oil. Good filling was secured in the cavity of the upper lobe. This can be accomplished only by careful posturing. The roentgenogram showed the large size of the tuberculous cavity. The patient improved after thoracoplasty, and I had a letter recently which stated that she raised almost no sputum.

CASE 7.—Miss M. had a nontuberculous abscess of the lung, in which there was enormous cavitation in the upper lobe. The injection of iodized oil showed that it was much larger than had been expected. The result of resecting the upper eight ribs was surprisingly good. She soon raised almost no sputum.

CASE 8.—W., a man, had a large chronic empyema following a bullet wound received in the World War. The value of the use of iodized oil in the diagnosis of a pleurobronchial fistula was shown in this case. The iodized oil ran through the fistula and partly filled the empyema cavity. It also demonstrated, usefully, that the lung itself was practically normal, thus eliminating the possibility of a coincident pulmonary abscess. The patient was cured by a resection of the overlying ribs and a plastic closure of the pleural fistulous opening.

SUMMARY

In tuberculous cases, iodized oil should be used with caution. A simpler method of injection than the bronchoscopic probably is best because, no matter how carefully and skilfully this procedure is carried out, it taxes the patient's strength more than a simple supraglottic injection.

Injection of iodized oil in old thoracoplasty cases in which the symptoms persist is valuable. Roentgenograms taken after such injections reveal lesions that cannot be demonstrated by any other method.

It is useful at intervals during the progress of a several stage operation, for bronchiectasis or abscess of the lung, in order to estimate the amount and location of the disease that still remains.

ABSTRACT OF DISCUSSION

ON PAPERS BY DRS. SINGER, TUCKER, BALLON AND BALLON, STEWART, AND ARCHIBALD

DR. FREDERICK LORD, Boston: Experience with the injection of iodized oil has been limited. It seems to me that up to this time it has been of relatively limited value and that some caution should be exercised in its use. In the selection of cases, it is desirable to make the diagnosis without using it if possible. In the abscess cases this usually can be done. There are few cases of abscess, however, in which one does not see more than a dense shadow in the region of the abscess. Much depends on the character of the roentgenogram. An overexposed film or an underexposed film is not as valuable as one properly exposed. In those cases in which the abscess cavity is not clear, the cavity should be drained, the roentgenogram made, and this roentgenogram compared with the previous roentgenogram. In this way one can sometimes outline the cavity. By every means possible the effort should be made to make a diagnosis without the injection of iodized oil. In the films shown by Dr. Archibald, he called attention to the persistent presence of the iodized oil in the lung, and I have noted its presence for months after injection. This may be a disadvantage in the observation of progress of abscess cases in which one is undecided whether to operate. In this group, it is undesirable to have the affected region obscured for a long period by iodized oil. In selected cases, however, iodized oil has been of material assistance. We have been able by its use to determine the site and extent of abscess cavities not otherwise to be found. This is especially true of lesions situated behind the shadow of the heart. In these films, one should notice how frequently the

iodized oil overflows from the side in question to the other side. I cannot believe that it is desirable in tuberculosis to flood the respiratory tract with any fluid and allow the contents of the bronchi to overflow with that fluid to uninfected parts of the lung. In one nontuberculous case of lung infection pneumonia developed on the opposite side from that in which insufflation was performed. How far the iodized oil, which had overflowed into that side, was responsible cannot be said; fortunately, the patient recovered.

Dr. A. L. Lockwood, Toronto: I have had a limited experience in the use of iodized oil—only thirty odd cases in human beings and eighteen or twenty instances in rabbits and dogs. I have been prejudiced against it because of some unfortunate experiences in these cases. I was called to operate on the first patient I saw who had received an injection of iodized oil, for lung abscess; the picture was exactly the same as that shown in one of the slides here. I was impressed by the picture of abscess of the lower lobe. In spite of the fact that the patient was extremely ill, I suggested observation for some days to determine what course the condition was going to take. Following the injection of iodized oil, the temperature and pulse were maintained for three or four days, and then were elevated considerably. The injection had been made through a bronchoscope, which may have increased the fever apart from the iodized oil. On the seventeenth day the roentgen-ray examination was repeated. There was still a certain amount of shadow showing where the abscess was supposed to have been. However, the patient's condition was such that I suggested not operating for a while longer. The next day the patient's physician injected 30 cc. of iodized oil, and the peculiar shadow did not fill. I have seen three similar instances of that in this group. I think Dr. Phillip has a suggestion that may be valuable: that in some cases the iodized oil has run into the stomach and thrown this shadow, which it was thought was caused by iodized oil, into the lower lobe. I should not be surprised if this were true. One instance in a rabbit might have been the same. On the whole, my attitude in regard to the use of iodized oil is that unless I had a serious case and was going to get some real benefit from its use, I should not want anything like iodized oil put into my bronchial tree. If there was a doubt as to whether I had an early bronchiectasis or some vague type of lung abscess or early tuberculosis, I should prefer to go to a sanatorium for a long trial of sanatorium treatment. I would go to Tuscon, Ariz., for a year or two and see what the dry climate and heat would do rather than take the chance of having iodized oil used and having the condition aggravated.

In the case of lung abscesses I am inclined to agree with Dr. Lord that with repeated stereographic roentgenograms, taken obliquely and laterally, and after emptying the abscess, a positive diagnosis is likely to be made in those cases. I think it has been definitely shown that the bronchoscope should be used as a matter of routine in all cases of vague bronchial disturbances. The bronchoscope causes recurrence in a certain percentage of patients, so that it is difficult to say whether the iodized oil adds to this condition.

I had thought that the proper way to make injections of iodized oil was through the bronchoscope, but I am pleased with the suggestion of Dr. Singer, and I have tried the method on some rabbits. What happened in these rabbits was this: With the first injection given, there apparently was little reaction. Necropsy was performed on some of these, and the iodized oil solution still remained in the bronchioles, but little evidence of irritation was seen. But with a second or third injection a definite bronchiectasis can be produced. I should like to hear the unfavorable reports of the use of iodized oil, how many accidents have happened in its use, not only from the reaction attributed to the iodized oil itself but

incidental to the method employed. Not long ago I was hurriedly called to an operating room where a careful surgeon had given an injection of iodized oil by injecting it through the cricoid cartilage. Immediately the patient began to cough, causing a hemorrhage. It was not an alarming one, but he apparently was aspirating the blood and coughing it out. The patient's condition was alarming for half an hour. A marked febrile reaction followed and persisted. It will be extremely interesting to note whether lung abscess or bronchiectasis will result. I believe that in employing that type of injection one will get a fair percentage of patients who will develop a reflex spasm with coughing and that the iodized oil solution is going to be aspirated back into the other lung and even into the stomach, so that the use of this type of injection is questionable. I feel that in the use of iodized oil as a diagnostic measure by the members of this society probably not many accidents would occur, but if the method was broadcast throughout the country as a safe procedure and all physicians began using it, I am not so sure that the accidents and the ill effects would not offset the value. I should like to hear from the various members of the number of patients they have seen with ill effects following the injection of iodized oil. I have talked with several of the members who have employed the method, and each one had seen some serious ill effects of the injections. One man mentioned that in injecting the solution the needle was broken off in the throat, and he had great difficulty in getting it out. Such incidents must be borne in mind in encouraging the wide use of such diagnostic methods. The fact that for years bronchoscopic examination has been contraindicated in patients with pulmonary tuberculosis seems to have been forgotten even by members of this society in their zeal to inject iodized oil through the bronchoscope.

I believe that the use of this oil is valuable in diagnosis in vague intrapulmonary conditions. It is, however, a diagnostic refinement not free from ill effects and dangers, and should be reserved for use only in those cases in which it is felt that if the diagnosis is made certain more definite treatment may be given.

Dr. Franz Torek, New York: May I suggest that in cases in which iodized oil is injected, after the patient has been placed in the upright and lateral positions, he should be placed on a table that can be turned readily to the Trendelenburg posture? Iodized oil enters the bronchial tree by gravity, and the roentgenograms presented here, for instance, those presented by Dr. David Stewart, show that the iodized oil is found almost exclusively in the lower part of the lung, probably because those injections were made in the upright posture. In the roentgenograms Dr. Singer showed in which he had placed his patients on the side, there was a much better distribution; a large portion of the bronchial tree was shown in the central portion of the lung. But in all the roentgenograms there is a failure to demonstrate the upper bronchial tubes satisfactorily.

Dr. Carl A. Hedblom, Chicago: In my opinion, the introduction of iodized oil is likely to prove to be one of the most important additions in recent years to the armamentarium in the diagnosis and checking of results of treatment in thoracic surgery. This opinion is based partly on the result of my own experience, partly on my impressions of the reported experiences of others and on the demonstrations made here. It is true that any method can be abused. I believe that the use of it is scarcely warranted when the diagnosis is clear without it. But in the differential diagnosis of disease of the bronchial tree, particularly bronchiectasis, in my opinion, it will prove indispensable. I have studied a series of more than 400 cases of bronchiectasis, in 28 per cent of which it was impossible to determine from the physical observations and roentgenograms whether the disease was unilateral or bilateral. The diagnosis probably was mistaken in many of the

36 per cent of cases judged to be unilateral and in the 36 per cent diagnosed as bilateral, in spite of the fact that the disease in most of these cases was of advanced grade.

I recall one case in particular in which the patient was raising upward of 100 cc. of sputum. The combined diagnostic facilities of the Mayo Clinic were not sufficient to establish which side the pus came from, and bronchoscopy left the matter more or less in doubt. This was, perhaps, due to the overflow to the other side. In 36 per cent of cases the diagnosis was unilateral and in 64 per cent it was bilateral. No doubt, from the facts brought out, we were wrong in a considerable number of cases as to the causes involved. It seems certain that early cases and those of the dry type described especially by French writers have been in large part overlooked. Large numbers have been wrongly diagnosed as cases of tuberculosis. I have had little experience with the method in cases of tuberculosis, and I should not want to make any statement as to its possible harmful effect in that condition. It may prove of considerable value in checking the result of operations, particularly thoracoplasty and the cautery extirpation of Graham, as Dr. Archibald has just mentioned.

As to the method, in the Mayo Clinic we have used the transtracheal route, a little local anesthesia, puncturing the cricothyroid membrane with a needle which is attached to a rubber tube so as to allow for movement of the patient without breaking the needle, and we have not had any bad effects either at the time of injection or later. We have been able to differentiate unilateral from bilateral bronchiectasis with certainty in cases in which we would not have been able to do so without the use of some contrast medium. We have also found it useful in studying cases of empyema with and without bronchial fistula. In a case of pulmonary tuberculosis in which the roentgenogram showed an annular shadow, we were unable to satisfy ourselves as to whether or not we were dealing with a cavity. The injection of iodized oil demonstrated the fact that the annular shadow is not due to a cavity and also shows the pressure of some bronchial dilatation.

A young boy had a history of cough with sputum, loss of weight and fever, but without any bacilli having been found in the sputum during a period of two or three years' observation elsewhere. The diagnosis with which he came to the clinic was abscess of the lung or empyema of the apical regions, with a bronchial fistula. We demonstrated a pleural cavity at the apex. In order to establish whether it communicated with a bronchus, we injected iodized oil into the trachea. Roentgenograms then showed the pressure of the fluid in the cavity, proving the presence of a bronchial communication with it. Later, tubercle bacilli were found in the sputum.

DR. HOWARD LILIENTHAL, New York: A woman had had a complicated abscess of the right upper lobe for a year and a half following an operation on her nose. It was a putrid case. All measures had been tried—bronchoscopy lavage included—and when I came to operate I saw why washings had failed. It was because the pus was inspissated like putty. I operated on her rather high in the axillary line and succeeded in emptying the abscess and producing a good sized bronchial fistula. The patient did well, and the roentgenograms showed no cavity. I wanted to know whether it would be wise to take out the tube and allow the bronchial stoma to close, which it seems inclined to do. Dr. Lewis Gregory Cole and I placed this patient with her head low and injected iodized oil into the bronchial stoma.

Before injection the roentgenogram showed that there was some iodized oil in the lower bronchus which had been there for more than six months, showing how long the oil remains. In the roentgenograms taken after the injec-

tion of iodized oil, small cavities are clearly visible. The case is a complicated one. I should like opinions as to whether it would be better to leave the tube out or not. The patient is not coughing now. No pus comes from the tube, only mucus. She coughed after the iodized oil was injected and drove some down into the other lung. Of course, mucus or mucopus would not be driven into the other lung so easily. Iodized oil, which is a pure liquid, is easily driven into the other lung. I believe that there is a real danger in using any liquid substance, iodized oil or anything else, in this manner, because it may wash infection from one side to the other.

One word about tuberculosis: I asked Dr. Gehrcke of Brauer's Clinic what they were doing with iodized oil. He said that they were afraid to use it in tuberculosis because they found that it spread the disease; sometimes they did not use it until from one to three months later. There had been some immediate bad results as well. It takes implantation tuberculosis a long time to produce physical signs, and it may be that some of the patients that are not immediately harmed by the iodized oil may show bad effects later. I therefore agree heartily that physicians should be slow to use iodized oil in tuberculosis.

Dr. David T. Smith, Ray Brook, N. Y.: I should like to say a few words in favor of the simplicity of the method Dr. Pritchard described. Dr. Pritchard visited us at the New York State Hospital and demonstrated his method on six patients, subsequent to which I began to use injections of iodized oil. Without any special training in nose and throat work, I attempted to make injections into thirty consecutive patients and succeeded in twenty-five. The method requires no special apparatus other than a laryngeal mirror, a laryngeal syringe and a fluoroscope. One assistant is an advantage but not a necessity. The patients do not object to the procedure. I spray a little cocaine in the back of the throat, largely for psychologic effect. In this series of thirty cases there were no bad effects, although every one of the patients swallowed some of the oil.

Dr. John D. Kernan, New York: One of the physicians in discussing Singer's method of using iodized oil said that he thought a great deal of it; as a bronchoscopist, in a way, I do not value it at all. To a bronchoscopist it is a horrible method. The idea of injecting a definite amount of iodized oil into the lung to go where it happens to go makes me tremble with rage and wrath. On the other hand, I must confess that the roentgenograms are equally astonishing. They are excellent. I am surprised that such good roentgenograms result from such a poor method. I wish that the late Dr. Lynah were here to see how his idea has grown, for I am sure he was the first one to inject liquid opaque substances into the lung in 1920 and through a bronchoscope, in 1920 and 1921. I have not seen his roentgenograms surpassed here. He and Dr. Stewart made roentgenograms six or seven years ago. As I immediately succeeded him at Lenox Hill Hospital, this work is not such a nine-days' wonder to me. The objection to this spilling-in method, I might call it, is that although it shows certain things that are there, it does not show what is missed. Dr. Tucker brought this out well: How does one know that above the dilatations that can be seen there is not a foreign body, a mass of granular tissues, a stricture or a new growth? These things are missed if a bronchoscope is not used. To me an otologist might as well fail to use his mirror and speculums as a lung surgeon or physician fail to use the bronchoscope in these lung lesions.

Dr. Willy Meyer, New York: Dr. Kernan has mentioned the work of the advanced bronchoscopist and the name of Dr. Henry L. Lynah. I also should like to speak of this man who unfortunately now belongs to history. Certainly if any of the, unfortunately, older specialists in this association, next to Dr. Chevalier

Jackson of Philadelphia and Dr. Yankauer of New York, has advanced this branch of medical science, Dr. Lynah has done so. In Boston at a meeting of the American Medical Association six or more years ago, he showed roentgenographically for the first time, before the section on laryngology, the results of his carefully planned injections of bismuth oil into the bronchial cavities.

The advantages that bronchoscopists offer for diagnosis and treatment when they do their work carefully should not be overlooked. If it is made a rule to ask their help, much better operations will be performed on the lung. Sometimes it is possible to diagnose conditions the existence of which would not have been known if injections of the oil had not been made. Dr. Lynah and his specializing colleagues were and are able to tell from what lobe or lobes the pus is being discharged, without jeopardizing the patient's life. In the hospital of which I am a member of the staff, there was only one case among many hundreds in which bronchoscopy was used in which for some unknown reason the patient suddenly died of shock while on the table—not from subsequent pneumonia. Of course, all surgeons have seen severe reactions after bronchoscopy. These are to be expected in conditions of inflammatory origin in the lung after local instrumentation. If I had a case in which I wanted to use iodized oil, in spite of Dr. Singer's ingenious method I would rather not have the oil instilled into the trachea. The bronchoscopist, under the guidance of his eyes, can introduce the oil into the place he wants it and nowhere else. That must prove the safest method for the patient. Guidance by the eyes has greatly advanced the therapeutics of disease conditions of the lung as far as diagnosis and conservative treatment are concerned.

Dr. A. L. Lockwood, Toronto: I distinctly want it understood that I had no idea of advocating the abandonment of the use of the bronchoscope for iodized oil. I simply want to congratulate Dr. Singer on his method. If such a simple method can be used to get such excellent roentgenograms, it should be approved.

Dr. J. J. Singer, St. Louis: I stated definitely that those who used the bronchoscopic method are people who know how to use it. I do not know how to use it; so I had to use another method. It would not be fair to let this symposium end with a comparison between the use of the bronchoscope and the use of iodized oil, in lung mapping. That is not being discussed, only the methods of using iodized oil. Various physicians have shown various ways of introducing it and the different ways in which they have made their diagnoses. The bronchoscope will do what iodized oil cannot do. Only the larger bronchi can be directly visualized. The bronchoscopic method of introducing oil shows more iodized oil spill-overs in roentgenograms than occur in just placing the patient as shown in my roentgenograms. If a roentgenogram is the only thing desired, one would not use a bronchoscope in the patient when making a roentgenogram. Why make roentgenograms at all? One may take a bronchoscope and look. For the sake of argument, I would agree that there is nothing better than direct inspection of any cavity. When conditions make that impossible, physical signs are used. But a continuation of this subject would introduce a discussion of bronchoscopy. There are five bronchoscopists in the hospital of which I am a member of the staff.

What is the value of iodized oil? A picture is painted that the operator thinks is there. His imagination may go off on a tangent, but just as soon as he knows what to "paint" he does not need 20 or 30 cc. of iodized oil; sometimes 5 cc. will do. I will say that it is as good for localizing as a bronchoscope. One can put it in the upper lobe or the middle or the base. There is no doubt that the oil can be put in the upper almost as easily as in the lower lobes. When

you stop to consider it, not every one is using iodized oil. This is a new method in this country. Every one is learning. That is why the members of this society are here. They are here to hear what the other fellow has to say. Every one wants to learn.

If a substance has been used for three or four years, and used extensively, in South America and in France and in England and in Germany, and no deaths or serious results are reported, it must have merit. The use of iodized oil should not be condemned because a few mishaps have occurred; it is one of the best aids we have in pulmonary diagnosis.

Dr. Gabriel Tucker, Philadelphia: Dr. Stewart, speaking of cases of bronchiectasis, mentioned that the condition often followed the infectious diseases of childhood. In reviewing the histories of chronic cases of bronchiectasis in adults, one finds that they began in childhood. The opportunity has been presented to examine many children who have suppurative conditions of the lung following these chronic infections. The good results obtained by use of the bronchoscopic treatment are remarkable. There has been a large percentage of cures in children by bronchoscopic drainage with local medication, and bronchiectasis in later life has been prevented in these patients. I feel as Dr. Kernan does about all blind methods of introducton of opaque substances into the lungs, in cases in which there is no contraindication to bronchoscopy. In our clinics, we use the bronchoscope in tuberculosis unless there are special indications. A diagnostic bronchoscopy is performed and the patient is kept under observation for several days, when a second examination is made and bismuth subcarbonate or iodized oil is introduced through the bronchoscope. The choice of the opaque substance depends on the bronchoscopic and roentgen-ray observations. No unfavorable results have been obtained with this method in either diagnostic bronchoscopy or pneumonography.

Dr. David A. Stewart, Ninette, Manitoba: I have nothing to add except to say that in thirty or forty cases in which iodized oil has been given by the supraglottic method apparently no harm has been done. Dr. Stuart Pritchard of Battle Creek says the same of 1,600 injections by the same method. I believe that physicians should make much greater use of it than they do of the bronchoscope. But it seems to me that there are a great many cases in which iodized oil can properly be given without the bronchoscope. Perhaps some of the children with cough and expectoration Dr. Tucker spoke of might have been cured by rest without bronchoscopy. It is an excellent treatment in the earlier stages.

Dr. David Ballon, Montreal: The great value of iodized oil lies in the fact that it permits a differential diagnosis between suppuration coming from the pleural cavity, from the lung and from the bronchi.

There is a man in the service of Dr. Archibald in the Royal Victoria Hospital at present who was wounded in the World War ten years ago. He received a bullet wound which entered in the region of the left nipple and made its exit near the spine. Since then he has been wandering around from sanatorium to sanatorium suffering from hemoptysis and purulent discharge. The diagnosis was lung abscess or bronchiectasis. As he was receiving a government pension he was even accused of malingering. The results of roentgen-ray examination were negative. A bronchoscopic injection of iodized oil was given, and the diagnosis made with absolute certainty that the man has a bronchopleural fistula. Diagnosis had been impossible by symptoms, signs or ordinary roentgen-ray examination. Iodized oil has its greatest value in bronchiectasis. I have seen no ill results from it. I have been using it in treatment for almost seventeen months. More than half of my patients with

bronchiectasis have been treated in tuberculosis sanatoriums. After treatment bronchoscopically with iodized oil they have been able to attend to their duties.

One of Dr. Archibald's patients, a student with bronchiectasis, who came from Washington, received bronchoscopic treatment from Dr. Birkett and was then able to take a course at the university. It has been possible to visualize the associated bronchiectasis with pulmonary tuberculosis. Furthermore, iodized oil has a definite therapeutic value in bronchiectasis. Two of my patients had bronchiectasis for a great number of years. I have given them injections of iodized oil, and cough and suppuration have diminished. They are feeling and sleeping better. One man who has received bronchoscopic treatment for a number of years has gained 40 pounds (18.1 Kg.) in weight. One girl treated in the outdoor clinic has gained 17 pounds (7.7 Kg.) in five months; she received bronchoscopic treatment combined with iodized oil.

The originators of the method have been internists and consequently have had to use other than bronchoscopic methods. But I firmly believe with Dr. Willy Meyer, Dr. Kernan, Dr. Tucker and others that in the future the best results in diagnosis will be obtained by the bronchoscopic method.

Dr. Scrimger operated in a case of lung abscess. The abscess was adequately drained, but for some unexplained reason the patient was not doing well. He asked me to make a bronchoscopic examination. I found the left main bronchus blocked with granulations. Snippings were taken and iodized oil was then injected. The pathologic report was primary carcinoma of the bronchus. Unless an abscess cavity is aspirated, it will not be possible to fill it satisfactorily. Iodized oil has been of value also in the diagnosis of abscess of the lung. In some of these cases in which the abscess cavity is filled, the iodized oil stops short and leaves a silent area.

There will always be ill effects when the oil is injected when the patient is moribund. A patient with acute pneumonic phthisis was referred to me to be given injections, with the obvious results. These patients should never receive injections. After treating this patient, a few months ago, I was asked to make a bronchoscopic examination on a person who was moribund. I examined the larynx and found a complete left recurrent paralysis. I refused to examine him unless the attending physician, who requested the examination, was present. As he was not present, the examination was postponed. The patient died that afternoon.

In regard to the different methods, all except the bronchoscopic are blind methods.

Dr. Edward Archibald, Montreal: In no other society could one hear so wide an authoritative expression of opinion on this new method of diagnosis as in this society. Men are gathered here who are particularly interested in the refinements of diagnosis, who are keenly alive to all that is new, and who probably represent the majority of those who are using iodized oil for this purpose at this time. In that sense I think we may congratulate ourselves on this opportunity for exchanging ideas.

NONTUBERCULOUS PULMONARY DISEASE

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There are three classes of persons interested in the correct diagnosis of the nontuberculous form of pulmonary disease, the physician who is the responsible adviser in the case, the friends of the patient and the patient himself. It is true that this community of interest obtains in practically all diseases, but in tuberculosis there is the question of sanatorium treatment, a protracted illness and much time lost from one's occupation in order to effect a cure, to say nothing of other possible results, so that more than ordinary interest attaches to cases in which the question of tuberculosis is raised. The answer is not infrequently difficult.

With this group of three, another may be mentioned, the sanatorium physician to whom these patients with tuberculosis are sent. Reports from various sanatoriums show that patients with nontuberculous pulmonary diseases are constantly being sent to these institutions and constitute from 25 to 50 per cent of the patients admitted. These observations alone compel occasional emphasis on a subject that a prominent internist years ago regarded as old and well recognized. There is need of being constantly reminded of the teachings of the older clinicians, lest their precepts be forgotten. It is on this account that I venture to speak briefly on this somewhat frequently discussed topic.

As sequelae of pneumonia or of bronchopneumonia or of influenza—as well as of pleurisy and of bronchitis, and in many cases in which no such relationship can be traced—European and American writers have discussed different types of chronic nontuberculous pulmonary disease. Feissenger, in 1889, Pfeiffer, in 1893, and Morel-Lavallee, in 1897, described protracted cases of pulmonary disease, including bronchitis and pleurisy following influenza. In this country it would appear that Lord, in 1902 and in 1905, was the first to emphasize the importance of this subject in his report of nineteen cases, in which were included eight patients acutely and eleven chronically ill. Careful microscopic studies were combined with physical examinations. In seven of the nineteen cases, tuberculosis was suggested by cough, and physical signs in the chest were persistent for months and even years. In three cases, the lung apexes were involved. Lord found influenza bacilli in the sputum of these patients for long periods. He says that the subjects of such infection, who are continually harassed by a troublesome cough, more or less abundant sputum, dyspnea, occasional rises of temperature for brief periods, localized bronchitis and doubtful or certain signs of consolida-

tion, are frequently thought to have phthisis. This is particularly true of the protracted acute or the chronic cases. Pal [1] states that he has observed several instances of catarrh of a pulmonary apex in patients showing disease of the nasal passage. Disappearance and reappearance of the râles run parallel with the condition in the nares. It would scarcely be profitable although interesting to follow the historic aspect of this subject further. Suffice it to say that comprehensive contributions to the literature are being made from time to time, bringing about a clearer understanding of this important subject.

The pathologic lesions in the chronic cases are practically those of bronchitis and fibrosis wtih bronchiectasis and areas of bronchopneumonia varying in size. The pleura is involved in many cases and peribronchial adenitis undoubtedly exists, while more or less widespread emphysema is induced. Lord, who had little opportunity to study the pathologic material in his cases, advanced the theory that small patches of the original bronchopneumonia broke down into minute abscesses which discharged into the bronchi, inducing a chronic bronchitis. Recently, MacCallum's observation on pneumonia following measles in soldiers showed that there was a rapid organization of the inflammatory exudate involving alveoli, bronchi, interlobar septums, the adventitia of the blood vessels and the lymphatics. If these changes were found in the dead, doubtless to a less extent, i. e., in smaller areas, such lesions may induce changes more or less permanent in the lung of patients who are recovering. This would account for at least a few cases in the group under discussion. Fibrosis, emphysema and bronchiectasis, which result from the changes described, are promoted to a large extent by superimposed infections, more or less acute, with the various forms of streptococcus and staphylococcus and the influenza bacillus.

Klotz has pointed out that the end-results of the pneumonic process in influenza are far more complex and indefinite than in lobar pneumonia. From his observations in the Pittsburgh cases during and after the epidemic of 1918-1919, it would appear that after influenza the lungs are damaged in proportion to the extent to which purulent pneumonia is associated with capillary thromboses, organic destruction, abscess formation and reparative processes. In some instances these areas may be so small as to pass unnoticed, while in other cases the process may be so widespread as to compel attention by both symptoms and signs.

DIAGNOSIS

Tuberculosis is the most common cause of chronic pulmonary disease, and the history of tuberculosis in a family is common when one surveys the intimate as well as the remote history of a patient. Pleurisy

1. Pal, J.: Med. Klinik **20**:1726-1727 (Dec. 7) 1924.

also is a fairly common disease, and one that we associate with an early tuberculous infection. The idea prevails in the minds of many physicians that influenza predisposes to tuberculosis. If one takes the total of these three impressions, whether or not they are sound opinions, one finds a reason for suspicion in all cases in which there is cough, expectoration, weakness and occasional short runs of light fever. If one adds to these the results of observations carefully made, pain in the chest, râles, apical signs and shadows of increased density in lung areas, one has good grounds for suspecting such cases as being due to tuberculous infection; hence, there is great need of care in differentiation.

To this already long list one must add still other features suggesting tuberculosis. Reference is made to blood in the sputum, actual hemoptysis, and the false or mistaken interpretation of roentgenograms. Hemoptysis has been observed in nontuberculous disease, and a few patients have returned from the roentgen-ray department with reports of chronic or active tuberculosis. As so many of these suspected cases follow influenza and the history of influenza is thus likely to bias the mind of the inexperienced in medicine, it is of interest to quote Fishberg on this traditional relationship:

> Contrary to the teachings of writers of previous generations, the recent epidemic of influenza has shown that this disease is not etiologically related to tuberculosis. Of the hundreds of cases which have come under my observation during the past year in which cough, expectoration, fever, etc., have persisted after an attack of influenza, only one turned out to be tuberculosis. The pulmonary sequelae of influenza are hardly ever tuberculous in nature.

The physical signs in nontuberculous pulmonary disease are those of bronchitis of one or a part of one lower lobe or even of both lower lobes; rarely are these signs found in the upper lobe. The signs are persistent yet variable. Later the signs of emphysema may develop. The roentgenograms show varying degrees of fibrosis. Constitutional symptoms of tuberculous infections are in the main absent, while tubercle bacilli are constantly absent from the sputum. The diagnosis on the basis of bacteriology has been urged, but this is obviously extremely difficult.

As I wish here to comment on the late results of nontuberculous lung inflammation, I will report illustrative cases.

REPORT OF CASES

Case 1.—A Jewish pedler, aged 45, had periodically frequented my service in the outpatient department of the Royal Victoria Hospital for several years. He also had been a patient in the ward on two or three occasions. The onset of his illness had appeared to date from an attack of pneumonia fifteen years before, from which he had made a tardy recovery. As this illness had occurred in Russia, details were unavailable. The patient thereafter was subject to frequent "colds." After coming to Canada, he had carried his merchandise about the country, walking the greater part of the time.

Cough, expectoration and occasional hemoptysis were his chief complaints. The pulmonary signs corresponded to those of chronic bronchitis, with many fine râles over both pulmonary bases. The heart showed no valvular lesion. The sputum was free from tubercle bacilli on many examinations, and as hemoptysis was regarded at that time as significant of pulmonary tuberculosis, elastic tissue was looked for frequently, with equally negative results. Constitutional evidence of toxemia was absent in this patient. He was not emaciated. The roentgenograms showed increased detail along the bronchial tree and greater density in the hilum of each lung. In short, bronchitis and fibrosis were the chief pathologic changes noted.

Several years later, the patient showed increasing dyspnea with cyanosis and marked signs of emphysema, which are the natural results in many patients with this history.

Case 2.—L. C., a woman, aged 48, was admitted to the hospital, Dec. 1, 1924, for sore throat, cough and expectoration, loss of weight and strength and pains throughout the chest. She said that she had had influenza twice in childhood. In the epidemic of 1918 she had had an attack of influenza followed by pleurisy, with effusion, and had spent about four months in bed. She stated that she had had frequent "colds" since, and had needed treatment by a rhinologist, who said that she had "sinus trouble."

On admission and for ten days before, the temperature was febrile. There was copious, occasionally blood streaked expectoration, probably largely from the nasopharynx. The physical signs of pulmonary disease were found mainly over the left lower lobe, where the percussion note was somewhat impaired; the breath sounds were weak, and many moist râles were heard. Over the right base also a few fine râles were heard. On roentgen-ray examination, the bronchial tree showed an increased shadow throughout, with thickening at each hilum. The fever subsided, the pulse was not accelerated and the sputum became less copious; improvement was slow. During the last two years, she has improved and gained in weight, yet she is still subject to "colds," with cough and expectoration. No acid-fast bacilli were found in the copious mucopurulent cocciladen sputum.

Case 3.—E. B., a woman, aged 49, was taken ill with headache, fever, malaise, sore throat, hoarseness, cough and expectoration; later, vomited after taking food. When seen in consultation with the family physician she presented the appearance of one greatly prostrated with an acute pulmonary infection. At the age of 39, the patient had been at Saranac Lake for several months taking treatment for pulmonary tuberculosis of the right apex, which now gave signs of fibrosis. Elsewhere throughout both lungs were found the signs of bronchopneumonia, chiefly in the left lower lobe. The sputum was not blood stained, and was always scanty. Tubercle bacilli were never found, although several examinations were made. The fever lasted fifty-nine days, after which improvement was uninterrupted.

This case was one of an acute bronchopneumonia superimposed on chronic arrested pulmonary tuberculosis of ten years before without unfavorable sequelae after four months' observation.

When first seen, anxiety regarding the type of disease with which one had to do in this case arose from two points of view: First, was the process one of tuberculosis from the beginning? If the bronchopneumonia was due to other organisms, how would the disease affect

the lesion now practically ten years quiescent? In answer to the first question, it may be stated that the character of the onset was against the view of an acute pulmonary tuberculosis. The condition began with pharyngitis, laryngitis and tracheitis, with constitutional symptoms and pulmonary signs after a few days, which is a rare sequence in pulmonary tuberculosis but a common one in a catarrhal bronchial infection which later shows definite signs of bronchopneumonia. The second question was as to the way in which this acute bronchopneumonic process would affect the lesion now practically ten years quiescent. At the present time, four months later, her physician says that she is as well as she was two years ago.

CASE 4.—E. W., a woman, aged 40, had intercurrent nontuberculous pulmonary disease of nine months' duration associated with the first attack of pernicious anemia. The patient was admitted to the Royal Victoria Hospital in December, 1923, complaining of cough, expectoration, loss of weight, shortness of breath, pain in the left side of the chest, weakness and indigestion. For the last nine years she had had an indefinite history of nasal catarrh and colds. In May, after the extraction of several teeth, she had developed pleurisy on the left side and shortly after a similar condition on the right side, accompanied by cough and weakness. She had been sent to the mountains for recovery. While at Sainte Agathe another "cold" had developed, and occasionally she had noticed that the sputum was blood streaked. There was no history of any serious illness preceding this. She had worked as a housemaid, and was constantly troubled with "indigestion." For thirteen years varicose veins had bothered her, but they had compelled her to give up work only recently.

The patient was thin and pale. She was slightly febrile while in bed, the temperature falling low and showing a wide range. The pulse rate ranged from 80 to 100, even at rest. Cough and expectoration were present. The chest was long and narrow, the note slightly impaired over the apex on the right; prolonged expiration and fine crepitations were heard over the upper lobe and at the apex of the lower lobe on the right. Later, however, signs of bronchitis became more evident. Dry and moist râles were heard both anteriorly and posteriorly over both lungs, yet they were always more marked over the right and toward the apex. At the left base, the percussion note was shorter than at the right.

For fully eight weeks the temperature was febrile and signs of bilateral respiratory disease were noted throughout. The sputum which was examined frequently, was negative to tests for tubercle bacilli. The blood and spinal fluid gave no Wassermann reaction. Roentgenographic examination made on admission showed the bronchial tree intensified toward both apexes and bases. Mottling at the right base was suggestive of tuberculosis. This view was modified a month later, and the modification was confirmed three months later.

For several months this patient was suspected of having pulmonary tuberculosis, yet she failed to show the undoubted clinical evidence. Investigation of the blood and of the nervous system, as well as of the gastric contents, shortly after admission enabled us to say that she had profound anemia and subacute combined sclerosis with achlorhydria. In short, a diagnosis of pernicious anemia was made. After three months in the hospital, the fever subsided, the pulmonary signs greatly diminished, the anemia improved and the patient took on considerable weight, although the condition found in the nervous system remained practically unchanged.

CASE 5.—P. B., a man, aged 28, when admitted to the hospital, March 11, 1926, complained of pain and tenderness in the right side of the chest, cough, expectoration, hemoptysis, fever, night sweats, dyspnea, weakness and loss of weight. He gave evidence of serious disease. At 17 years of age he had had "pulmonary congestion," which confined him to bed for seven months. At 20 years of age, in the epidemic of 1918, he had been in bed two months with "Spanish grip." Each winter since, he had had "light grip." In June, 1925, he had suffered severe thoracic pain; later the cough had increased and expectoration had become more profuse, at times being definitely hemorrhagic. In this attack, which had lasted until August, 1925, he had noticed that the odor of the sputum was offensive. He had worked for a few weeks, but in January, 1926, the cough had become worse and the sputum once more showed blood. He had night sweating and was weak, yet he again improved, only to suffer a relapse early in March. Shortly afterward he came into the hospital.

He was weak, febrile and anemic, and had moist skin and marked clubbing of the fingers. The breath had a foul odor. At rest there was no dyspnea. The pulse rate was moderately increased. There was poor expansion and lagging of the right side on inspiration. Tactile fremitus was increased over the area of the right lung. Dulness was present from the third rib down. Signs of emphysema were present over the area of the left lung, with a few moist râles at the left base. The chief interest centered about the signs in the right side of the chest. The upper lobe appeared free. Below this, however, there were diminished breath sounds; moist and dry râles were widely heard. Moist râles were generally present. Sonorous râles were heard at varying intervals, while density or dulness was most marked in the middle of the area of the right lung. The roentgenograms taken before admission, i. e., in January and while the patient was in the hospital, indicated that there was thickening in both lower lobes, more pronounced, however, over the right, giving the suggestion of an abscess. Two months later, the roentgenogram suggested fibroid tuberculosis, with increasing and irregular shadows over the area; a right side cavity without a line of fluid level was suspected. An exploratory puncture over the dense area on the right failed to withdraw pus.

By bronchoscopy and injections of iodized oil, 40 per cent, bronchiectasis of both lower lobes was demonstrated. The sputum never showed tubercle bacilli, but *Streptococcus viridans* and nonhemolytic bacilli were found in a culture from the right bronchus. Elastic tissue was demonstrated on two occasions. The febrile condition lasted for ten days after the patient came to the hospital. Drainage was carried out. The sputum lost its foulness, lessened considerably in quantity, the density of the lung areas cleared, and the patient improved greatly. He was discharged, after seven weeks in the ward, to go to the country. To the present time, he has not reported.

CONCLUSIONS

The late results in these cases, as well as in practically all cases of the class under consideration, depend not only on the extent of the primary injury to the pulmonary tissue but also on the frequency of recurring and superimposed infections, and the type of infection. These results, too, we believe are dependent on circulatory disturbances, which in not a few instances are caused by toxemia and overwork acting on the heart muscle, impairing its efficiency and increasing the dyspnea, cough and expectoration, as well as the signs of chronic bronchitis.

ABSTRACT OF DISCUSSION

Dr. W. S. Lemon, Rochester, Minn.: In the survey of the cases that have come under my consideration, there seems to have been a certain order of events. The patients either were so desperately ill that they died quickly, within as short a time as twenty-four hours, and their lungs then were found to be not pneumonic but in a prepneumonic stage without consolidation, wet and dripping with blood, or those who had a little more resistance, or whose infection was less virulent, developed a bronchopneumonia that was so widespread that it became of the pseudolobar type. These patients, because of the oxygen unsaturation, usually were dyspneic and most of them died. Then a third group appeared which we know had definite bronchopneumonia. A larger proportion of patients survived. In those who lived long enough, complications appeared with intrapulmonary abscess formation, or with both intrapulmonary formation and empyema, and frequently it was possible to demonstrate the fact that the empyema was secondary to a subpleural abscess. Such patients are likely to have pleurisy, because almost invariably in diseases of the lung, whether acute or chronic, the pleura is affected to a greater or less degree. Finally, there was a group of patients who through the accident of virulence or of their own strength were able to overcome the disease to the extent that finally they suffered from only what was known as unresolved pneumonia. I think the term "unresolved pneumonia" should be used with a great deal of reservation, because I think it seldom occurs. But sometimes the alveoli which usually expand fail to do so, and then the lungs are subject to this type of infection which remains for years. From six months to a year following these epidemics, an increasing number of patients who had the disease known as nontuberculous lung infection presented themselves at the Mayo Clinic. Nontuberculous lung infection, it seems to me, has proved as time has passed to be the beginning of a bronchiectasis, because in bronchiectasis three things are usually necessary: infection, stenosis and inflammation. Infection was implanted and chronic, and it could be shown by examination of the sputum to be continuous. Stenosis is more difficult to explain, but two conditions can, perhaps, be included as being explanatory of it: first, the enlargement of the tracheobronchial lymph nodes, and, second, kinking of the diseased bronchi. The inflammation that remained and the enlarged glands or stenosis promoted secretion and cough, and the forced inspirational cough together with the absence of the usual elastic support to the bronchi, as well as the damage to the wall of the bronchus itself, permitted the appearance of estasis. So that in greater or less degree, sometimes with the condition impossible of diagnosis other than as chronic bronchitis, there were patients who had a productive cough over long periods of time; this was recurrent with each successive infection, with râles of different characters, usually in the bases of the lungs. Such a picture has been presented so many times that it seems to me that chronic nontuberculous infection is per se beginning bronchiectasis.

Dr. Frederick T. Lord, Boston: Dr. Stewart has already alluded to the tendency to discard the term "chronic bronchitis," and it is fair to say that this diagnosis is seldom justified as an explanation of chronic cough and expectoration. The most common cause of chronic cough and expectoration is cardiac decompensation and then in order of frequency come inflammatory pulmonary processes and uncomplicated chronic bronchitis for the most part only as a manifestation of bronchial asthma. In bronchial asthma a toxic bronchial disturbance may persist for long periods without giving rise to changes elsewhere than in the bronchi.

DR. D. A. STEWART, Ninette, Man.: Dr. Hamilton spoke of the many nontuberculous patients sent to sanatoriums as tuberculous. About a quarter of a century ago, a big antituberculosis campaign began, and the fact became generally recognized that tuberculosis was not a disease confined to those with gross symptoms, but was almost universal; at least, the infection was universal even if the disease was not. The pendulum swung definitely in the direction of presuming tuberculosis and putting the onus of proof on the one who would unmake rather than on the one who had made this diagnosis. Almost every pulmonary condition was suspected to be tuberculous unless positively proved to be something else. The great aim was early diagnosis. There is no doubt that there was much overdiagnosis of tuberculosis. Then came the war and the pulmonary infections that belong to the trenches, and the stream of men that came back with conditions diagnosed as tuberculosis. It will be remembered that 100,000 men were taken out of the French army and sent home because they coughed and expectorated, had blood in the sputum and fever, and that Rist organized a sifting out clinic and sent 80,000 back as not having tuberculosis. The idea began to grow then that although there was need for early diagnosis in these cases, accuracy was even more important. Then came the greater use of the roentgen ray, of the bronchoscope and of iodized oil, better bacteriology and better and newer surgical procedures for the chest, and so greater accuracy in diagnosis has begun. In the Phipps Institute a number of years ago, among patients classed as having far advanced cases of tuberculosis it was found postmortem that 10 per cent did not have tuberculosis but had other pulmonary conditions. I think that fully 50 per cent of the patients presenting themselves at sanatoriums for diagnoses may have nontuberculous conditions, but a much smaller number are sent to sanatoriums mistakenly as tuberculous. Differential diagnoses are much better made by general practitioners than they used to be. Common colds, pneumonia and influenza have more nontuberculous than tuberculous conditions as their sequelae. The early stages of septic lung infections are among the most common conditions met. I do not agree with Dr. Hamilton that all of these patients should be referred to surgeons. Improved methods in bacteriology, of which Dr. Smith has spoken, promise better means of medical treatment. It must be remembered that even those who have definite tuberculosis may have other conditions as well, and that tuberculosis reaches its most dangerous stage when there is mixed infection. There is a much better armamentarium than ever before. The sanatorium should make diagnoses of all conditions of the chest, and perhaps give treatment for them.

DR. FREDERICK T. LORD, Boston: As to the pathology of chronic nontuberculous lung disturbances and especially to the prevalent use of the term bronchiectasis, bronchial dilatation is the most obvious incident in certain of these chronic conditions, but it should be realized that from the pathologic point of view bronchiectasis almost never exists alone. The only condition in which, from a pathologic point of view, we find it existing alone is in cases of bronchial asthma. When there are bronchial dilatations in other conditions there are important changes in the lung and usually a much more important change in the lung than dilatation of the bronchi. These cases of so-called bronchiectasis of which the roentgenologists and the bronchoscopists speak are really more appropriately called chronic bronchopulmonary infections with or without bronchial dilatation, but the bronchial dilatations may be merely incidental to more important pulmonary lesions. The usual pulmonary condition in these chronic inflammations is fibrosis of the lung tissue with or without cavity formation and bronchial dilatation. As to the differentiation of the cases of tuberculosis from

this group of nontuberculous pulmonary infections, internists believe that there are certain ways in which this can be done in the absence of tubercle bacilli. In the first place, the evolution and grouping of the symptoms in the tuberculous cases is different from those in the nontuberculous cases, is an important point to consider in the differentiation. Any case in which there is a sudden hemoptysis is probably tuberculous, and those cases in which the hemoptysis is intercurrent with cough and abundant expectoration may or may not be tuberculous. Cases of primary pleurisy are most probably tuberculous. Cases in which there are signs of the disturbance toward the apical region are probably tuberculous. I say toward the apical region because it should be appreciated that pulmonary tuberculosis begins in the region immediately below the apex. Chief reliance may be placed on the roentgen-ray appearances, and any case in which on roentgen-ray examination one finds a finely or coarsely mottled increase of density above the anterior portion of the third rib is probably tuberculous.

DR. WILLY MEYER, New York: It was illuminating to hear Dr. Hamilton state that from 25 to 50 per cent of those presenting themselves because there is a likelihood of their being tuberculous are nontuberculous. In 1914 I read a paper on bronchiectasis before the meeting of the American Surgical Association at the time of its joint session with the International Congress of Surgery in New York. This was at the beginning of the treatment of bronchiectasis. In order to define clearly, I said that bronchiectasis is a disease of the bronchial tree, not of the pulmonary parenchyma. I knew that anatomically this was not absolutely correct. I have been severely criticized by a New York colleague for that statement. It was therefore interesting to me to hear today emphasized again that bronchiectasis is to be considered a disease of the broncho-pulmonary system.

I hope that it will not be thought that I am partial to bronchoscopy, but I feel that, when treating protracted conditions of inflammation of the lung, if the internist would work with the bronchoscopist he would secure improvement or cure in a number of cases more quickly. In this respect I recall one patient who was treated by the late Dr. Lynah. I diagnosed the case chronic bronchiectasis and referred the patient to him for intrabronchial therapy. It was surprising to see what was accomplished in the case of this girl, who every little while had had a recurrence of fever, increased sputum and other symptoms. The patient was at last so much improved that she considered herself well. She was an Irish girl, and much against our better judgment she returned to Ireland. There she soon began to ride the bicycle, dance and help with haying on the farm. She enjoyed life as others do for more than a year and a half, when she suddenly was taken seriously ill and died. Death may have been due to metastatic brain abscess with suppurative meningitis; this not infrequently has been found complicating chronic bronchiectasis. I wrote to the physician in Ireland, but could not learn the real cause of death.

The procedure with these patients who suffer from nonspecific chronic suppuration of the lung should be one of cooperation. Internist and surgeon examine and with the help of the laboratory make the diagnosis. Then the patient is referred to the roentgenologist for a refined diagnosis. After this the patient with acute, subacute or chronic condition is referred to the bronchoscopist. If he decides to treat the patient, the surgeons allow him to see what he can accomplish by means of intrabronchial treatment. A number of these patients were cured by bronchoscopic treatment. In view of such experience, is it not a duty to cooperate in these cases? Naturally, the bronchoscopist cannot cure every patient; he gradually refers some patients back to the surgeon.

A new addition to conservative surgical treatment was published by Sauerbruch a few weeks ago. It is for those with the subacute rather than the chronic cases of lung suppuration of the nonspecific type. He speaks of the surgical treatment of cavities near the hilum. How is it possible to get at these with greater certainty without eventually jeopardizing the life of the patient? The parenchyma of the lung must be traversed in order to reach such a cavity surgically. He has used the method of Baer, which some surgeons have used for tuberculous patients who did not respond with a complete collapse after extrapleural thoracoplasty. After apicolysis the cavity above the lung is filled with a paraffin plomb. In a number of instances—he mentions ten of these suppurating cases—Sauerbruch has resected several ribs with their periosteum, extirpated the intercostal muscles, exposing the parietal pleura. If he then saw by the motions of the lung that there were no adhesions, he did not proceed but used the paraffin, spreading it over an area the size of two hands on the parietal pleura. Then he turned back the muscles, sutured the skin completely and waited. In some instances this alone sufficed to compress the cavity sufficiently, and the latter healed. In other more aggressive cases, the compression and the changes that came about in the lung in from two to three weeks allowed the pus to perforate into the area about the plug. Then when the wound was opened and the plug removed, a number of perforations made by nature were seen. By enlarging them slightly and packing the wound with gauze the cavities near the hilum in ten patients were healed. I think that this treatment is an important addition to our conservative operative resources. But in some of these cases, if not too urgent, bronchoscopy might be successful.

I think it is agreed that in diseases of the thorax the anatomist and the physiologist, the chemist and the physicist, the internist and the surgeon, the roentgenologist and the bronchoscopist should cooperate. To continue the progress in the treatment of lung suppuration made in the last ten to fifteen years these various branches of medicine and surgery must never cease to work together.

Dr. Howard Lilienthal, New York: I was much interested in Dr. Hamilton's estimate of the great number of nontuberculous patients who come to a sanatorium with a diagnosis of probable tuberculosis. It is far in excess of what I should have expected. Hemoptysis has been referred to here as occurring early in tuberculosis without previous symptoms. We know that it does occur in the progress of the disease also, and that it may be dangerous, but I wish to call attention most emphatically to the danger of hemoptysis in nontuberculous conditions, especially in the putrid forms of suppurative diseases of the lung. If I may judge by what I have seen myself, the danger of death from hemoptysis in suppurative disease of the lung is great. When a patient begins to spit blood in quantity, that is a sign that some surgical procedure should be performed because the chances of his dying as a direct result of repeated hemorrhages are great.

I do not want to be too critical, but when Dr. Lemon speaks of forced inspiration as a cause of dilatation of the bronchi from which the rigid parts had vanished, I should like to take exception. I do not think that it is the inspiration; it is the spasmodic cough that forces the air down into these bronchi with weakned walls, producing expansion. This happens in cases in which foreign bodies have been partly impacted in a bronchus and in which the cough drives some air past the obstruction which cannot get back afterward. I have not proved it experimentally, but it stands to reason that the violence of the driving of air from the sound parts of the lung into the weakened bronchi with the closed glottis, as it occurs in cough, is a much more powerful influence than

mere expansion by inspiratory effort. Dr. Meyer spoke of meningitis as a fairly common complication of suppurative disease of the lung. I did not know of this pathologic sequence, and I am interested to hear that it occurs primarily without brain abscess. I did know, of course, that bacterial emboli and multiple abscesses of the brain are common in this disease.

Dr. Nathan W. Green, New York: Some years ago I conducted a series of experiments in the physiologic laboratory and in the course of the experiments I tried to raise the intrapulmonary pressure, in a simple way, by blowing into a tube connected with a manometer. I found that the positive pressure could be raised to 60 mm. of mercury. According to Donders the normal negative pressure in the pleural space in the human being is 7 mm. of mercury. So I think that, as Dr. Lilienthal says, the positive pressure exerted by the spasmodic cough would have more to do with the dilatation of the impaired bronchial tree than the forced inspiration as suggested by Dr. Lemon.

Dr. J. J. Singer, St. Louis: I agree with the other speakers that unresolved pneumonia is really not pneumonia. In most instances there is an inflammatory reaction in the lung which is pneumonitis rather than pneumonia. This pneumonitis may manifest itself in the form of abscesses that may show only a small ulceration while the induration around it may extend probably 3, 4 or 5 inches (7, 10 or 12 cm.). Here and there, there may be more breakdowns, and this breakdown represents what has been termed a carbuncle in the lung. I think that that description would fit in with many of the so-called cases of unresolved pneumonia. I have always felt that the bronchial tubes were nothing more or less than drainage tubes that carry the air into the pulmonary alveoli and send it back; that they are resistant to infection and bronchitis is really not the case. They exude pus from the lung rather than from their own walls. Infection of the bronchi is rare. In dogs one can put bacteria on the mucosa of the bronchial wall and get no infection. It certainly must be the same in human beings who bring up a large amount of pus, with rarely an increase in temperature. They are merely the drainage tubes. The inspiratory element has a part in the development of bronchiectasis, and so has the cough, but neither in itself produces bronchiectasis. There must be weakened extrabronchial tissue that has become infected and formed a sort of carbuncle. This weakens the walls not of but around the bronchi or the tissues around the bronchi, which form the structure around the bronchial tubes. When this tissue breaks down, ulcerates and is infected in these recurrent attacks of pneumonitis, a weakened wall around the bronchi results, and the deep pressure produced by taking deep breaths will eventually push the bronchi in this manner.

Dr. David T. Smith, Ray Brook, N. Y.: I should like to speak of the bacteriology of chronic nontuberculous pulmonary diseases. I would urge members of the association in choosing men to diagnose a case to include a bacteriologist with the roentgenologist, the bronchoscopist and the internist. In chronic nontuberculous infections of the lung there are probably many agents at work. The sputum in all these cases should be examined, and when bronchoscopists are available, I suggest that the bacteriologist examine material collected directly from the lungs. When the bronchoscopist is not available, good specimens can be obtained by brushing the teeth thoroughly several times with toothpaste, rinsing the mouth with a sterile mouth wash, then washing the sputum through several solutions of physiologic sodium chloride solution. The bacteriologic examinations should be made from the central portion of this washed sputum. Some of this material should be examined when fresh, unstained, and some should be examined in 10 per cent sodium hydroxide solution. The sodium

hydroxide digests the pus cells and the mucus and leaves in sharp outline any fungus that may be present in the sputum. By this method it has been possible to diagnose, at the New York State Hospital, one case of aspergillosis, two cases of oidiomycosis, five or six cases of moniliasis and one case of sporotrichosis. I cannot prove that these organisms were the cause of the nontuberculous disease, but in certain cases in which iodine was administered the organisms disappeared and the patients improved.

Cultures should be made for fungi because certain of the fungus organisms will grow when they cannot be seen in the pus, and in every case in which they are seen the diagnosis should be confirmed by a culture. Castellani recently described an anaerobic fungus that he found in certain chronic nontuberculous infections. Consequently both aerobic and anaerobic cultures should be made in every doubtful case. Many of the organisms in the lung are anaerobic, as Dr. Lambert has found, and simple aerobic cultures will give misleading results. I would suggest that smears be made of the material, and that they be stained by two or more methods. Smears should be obtained by the Gram method to show the variety of organisms, and then with some simple stain, such as methylene blue or gentian violet, to show whether fusiform bacilli are present or not. If fusiform bacilli are present, smears should be stained for spirochetes by the Fontana method.

Dr. Edward W. Archibald, Montreal: In regard to this subject, I have had ideas along lines that have not been discussed as far as I can find. I speak of lung scars remaining from unresolved infections or partially resolved infections which have been overcome and remain in a condition of chronic infiltration, or become actual scars with localized contraction of the contiguous lung tissue. Such cases, I have read, are frequently accompanied by dyspnea and shortness of breath on slight exertion, and the roentgen ray shows one or several areas of indefinite shadow. These patients are handicapped, but not seriously. There is no question of pus and none of the condition to which Dr. Lord has referred, chronic lung infection, of which dilatation of the bronchi is only a part. Excluding bronchiectasis, abscess cases, great interference with pulmonary aeration is shown by chronic infiltrations. This indicates that the condition should be classified as one caused by lung scars, characterized by shortness of breath and disability to perform a full day's work. Is there anything surgery or medicine can do for these patients? This leads to my question, which is: In such cases, is the shortness of breath due to any compensating emphysema in other parts of the lung or to a loss of the elastic tissue such as is found in chronic emphysema with the barrel chest, so that expiration rather than inspiration is difficult? Expiration is slow. If the answer should be that this emphysema is not due to the scar itself nor to any associated bronchiectasis or infection, is there anything that can be done? I would answer my own question partly by suggesting that a slight partial compression of the emphysematous lung be performed. Is anything to be gained by slight compression which could be provided by mild unilateral or bilateral pneumothorax kept up for a considerable time, one, two or three treatments to be ultimately substituted by a small thoracoplasty?

Dr. W. F. Hamilton, Montreal: There are several points in this discussion that interest me. The first was made by Dr. Stewart. I should have put the percentage in the reverse order, that is, from 50 to 25 per cent, 50 some time ago and 25 at present, with the increasing precision of diagnosis which is admitted to be present and which may be improved. Dr. Lord's remarks about chronic bronchitis pleased me greatly. For a long time I have held the idea that diagnosis of chronic bronchitis failed when attention was directed particularly toward the

bronchial condition, and the condition of the heart overlooked. I think that this is a frequent failing which is unnoticed, and which causes that symptomatology called chronic bronchitis. The emphasis laid on cooperation by Dr. Meyer is important. That ideal is constantly being more closely approached. In respect to bacteriology, I made one remark which I repeat now, that from the standpoint of bacteriology the diagnosis is obviously difficult. I agree with Dr. Smith in his plea for better methods of diagnosis. In hospitals, a large staff of well trained bacteriologists is required, and this takes money and time; whether such expenditure will be rewarded remains to be seen. I believe that the end is worthy of it.

EXPERIMENTAL ASPIRATORY ABSCESS*

DAVID T. SMITH, M.D.
RAY BROOK, N. Y.

The apparent increase in the incidence of pulmonary abscess, especially the postoperative form, has become a serious problem for both surgeon and physician. There are two important theories regarding the cause of pulmonary abscess, the embolic and the aspiration theories. At present each has about an equal number of adherents. The evident conflict between these theories is an obstacle to the adoption of satisfactory methods of prevention. Consequently, it would seem advisable at this time to attempt to appraise their relative value.

Included among the chief supporters of the embolic theory are Fetterolf and Fox,[1] and Cutler [2] and his associates. Cutler, in a series of ingenious and well controlled experiments, produced pulmonary abscess in the dog with infected emboli. However, he was unsuccessful in his attempt to produce a similar condition in dogs by the aspiration route. He concluded from these observations that most cases of postoperative abscess are embolic in origin.

Cutler and Schlueter [3] compiled from the literature 1,908 cases of pulmonary abscess, of which only 30 per cent were postoperative. They made no attempt to explain the remaining 70 per cent, stating that an abscess following pneumonia or bronchiectasis was essentially different from one developing subsequent to an operation. Apparently, this view is not supported by bacteriologic or pathologic studies. I compiled fifty-six cases from the literature (accompanying table) in which the predisposing cause was known and in which bacteriologic and pathologic studies had been made.[4] There was no essential difference noted between

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* From the New York State Hospital for Incipient Pulmonary Tuberculosis.

1. Fetterolf, G., and Fox, H.: The Paratonsillar Tissues in Relation to Posttonsillectomy Abscess, Proc. Am. Laryngol. A., 1923, p. 252.

2. Cutler, E. C., and Schlueter, S. A.: The Experimental Production of Abscess of the Lung, Ann. Surg. **84**:256 (Aug.) 1926. Holman; Weidlein, and Schlueter: A Method for the Experimental Production of Lung Abscess, Proc. Soc. Exper. Biol. & Med. **23**:266, 1926. Schlueter, S. A.; Weidlein, I. F., and Cutler, E. C.: The Experimental Production of Lung Abscess, New York State J. Med. **26**:767 (Sept. 15) 1926.

3. Cutler and Schlueter (footnote 2, first reference).

4. Buday: Histologische Untersuchungen über die Entstehungsweise der Lungengangrän, Beitr. z. path. Anat. u. z. allg. Path. **48**:70, 1910. Fishberg, Maurice, and Kline, B. S.: Spirochetal Pulmonary Gangrene, Arch. Int. Med. **27**:61 (Jan.) 1921. Kline, B. S.: Spirochetal Pulmonary Gangrene, J. A. M. A. **77**:1874 (Dec. 10) 1921. Kline, B. S., and Blankenhorn, M. A.: Spirochetal

the ten postoperative, the twenty-two spontaneous, the nine postbronchiectatic, the seven postpneumonic and the eight cases which complicated either pulmonary neoplasms or tuberculosis. In all the lesions, two or more of the following organisms were identified: spirochetes, fusiform bacilli, cocci and vibrios.

This peculiar assortment of organisms is frequently found in the tonsillar crypts and around the teeth in no less than 80 per cent of the population (fig. 1). To my mind this is a point of great significance in locating the source of the infection. In six cases of pulmonary abscess, three postoperative and three spontaneous, in which I examined with the dark field apparatus both the washed pulmonary sputum and the scrapings from the teeth, not only were the same morphologic forms

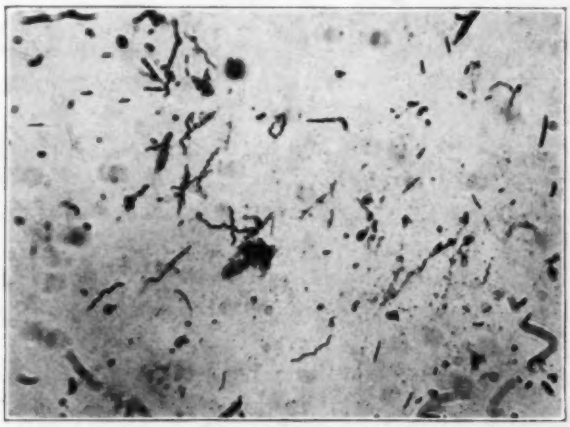

Fig. 1.—Spirochetes, fusiform bacilli and cocci from the gums of a patient suffering from moderately severe pyorrhea; fontana stain.

present, but their varying motility was identical, so that it was difficult to tell from the slide alone whether the material came from the teeth or from the lungs.

Furthermore, four cases are recorded in the literature in which gangrene or abscess of the fingers and hand followed a bite by human

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Pulmonary Gangrene, J. A. M. A. **81**:719 (Sept. 1) 1923. Kline, B. S., and Berger, S. S.: Spirochetal Pulmonary Gangrene Treated with Arsphenamins, J. A. M. A. **85**:1452 (Nov. 7) 1925. Lambert, A. V. S., and Miller, J. A.: Abscess of Lung, Arch. Surg. **8**:446 (Jan.) 1924. Peters: Hand Infection Apparently Due to Bacillus Fusiformis, J. Infect. Dis. **8**:455, 1911, Pilot, I.; Davis, D. J., and Shapiro, I. J.: Studies of Fusiform Bacilli and Spirochetes, Am. Rev. Tuberc. **8**:249 (Nov.) 1923. Pilot, I., and Davis, D. J.: Fusiform Bacilli and Spirochetes: Rôle in Pulmonary Abscess, Gangrene and Bronchiectasis, Arch. Int. Med. **34**:313 (Sept.) 1924.

teeth.[5] Examination of the pus from these patients revealed spirochetes, fusiform bacilli and cocci in three and fusiform bacilli and cocci without spirochetes in the fourth. These accidental infections, which are practically the equivalent of experiments on human beings, indicate that the organisms found about the teeth may, under certain conditions, become virulent for man. The foregoing observations offer strong presumptive evidence that the teeth and tonsils are the usual sources of infection in both postoperative and nonoperative pulmonary abscess.

If this view is correct, the question arises regarding the channels by which the organisms from the mouth gain access to the lungs. The following experiments were planned to determine this point.

EXPERIMENTAL REPRODUCTION OF PULMONARY ABSCESS

I attempted to produce pulmonary abscess in fifty mice, forty guinea-pigs, five rabbits and three dogs by intratracheal inoculation of bloody material obtained from about the teeth of patients suffering with moderately severe pyorrhea. The development of spontaneous lung abscess was not noted in any of the stock animals.

After the animals were anesthetized with ether, the trachea was dissected out and elevated to the skin surface. A small caliber needle was plunged through the tracheal wall and the infecting material injected so that it trickled down into the lungs drop by drop. The dose for mice varied from 0.05 to 0.1 cc.; for guinea-pigs, from 0.1 to 0.5 cc.; for rabbits, from 0.5 to 1 cc., and for dogs, from 3 to 5 cc. By varying the position of the animal, the material could be directed into either the right or the left lung. This technic offers no gross insult to the lungs, and simulates rather closely the circumstances under which an anesthetized patient aspirates material from the mouth.

Roughly, 30 per cent of the animals remained well, 50 per cent died of pneumonia and 20 per cent developed pulmonary abscess. The controls, ten mice and seven guinea-pigs injected with the same material rendered sterile by heating to 60 C., failed to develop pulmonary lesions. The absence of pulmonary disease in the fifteen mice and twelve guinea-pigs may probably be explained by natural resistance, by difference in dosage, by an active cough reflex which expelled the injected material from the lungs or by recovery from the infection.

Twenty-five mice and twenty guinea-pigs succumbed to pneumonia in from twenty-four to ninety-six hours following the intratracheal injections. Grossly, there was nothing characteristic about the pneumonic lesions; yet the stained smears showed spirochetes, fusiform bacilli and cocci, and anaerobic cultures yielded a growth of fusiform bacilli and streptococci. It is interesting to note that the animals that survived two weeks or longer, at necropsy showed no evidence of pneumonia; they either were normal or presented evidence of pulmonary abscess.

In the ten mice and eight guinea-pigs that developed abscesses (figs. 2 and 3), smears and cultures showed spirochetes, fusiform bacilli, anaerobic streptococci,

5. Hultgen, J. F.: Partial Gangrene of Left Index Finger, J. A. M. A. **55**:857 (Sept. 3) 1910. Peters (footnote 4, seventh reference). Pilot, I., and Meyer, K. A.: Occurrence of Fusiform Bacilli and Spirochetes in a Gangrenous Lesion of the Finger, Arch. Dermat. & Syph. **12**:837 (Dec.) 1925.

Fig. 2.—Lungs of a guinea-pig that one month previously had received 0.5 cc. of the pyorrhea material shown in figure 1. At necropsy, three separate, discrete, well walled-off abscesses were found which contained spirochetes, fusiform bacilli, cocci and vibrios.

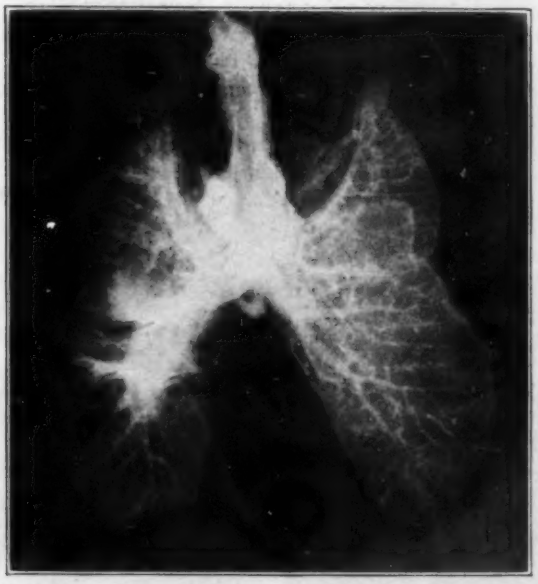

Fig. 3.—Lungs of a guinea-pig that had received 0.5 cc. of pyorrhea material ten days before necropsy. This abscess approaches the bronchiectatic type; in it were found spirochetes, fusiform bacilli, cocci and vibrios.

vibrios and rarely leptothrix-like organisms. As a rule, the guinea-pigs were killed two weeks after the intratracheal inoculations, but one old male pig that seemed well nourished was allowed to live one month, and at necropsy three well walled-off abscesses were discovered, each connected with a bronchus (fig. 2).

The dark field examinations of the pus from all the experimental abscesses showed organisms morphologically identical with those recovered from pulmonary abscesses in man.

Late in the investigation, it was discovered that rabbits also were susceptible to these organisms. One of the animals died eight days after receiving an intratracheal injection of 1 cc. of material obtained from about the teeth of a patient suffering from pyorrhea. When the thorax was opened, the left lung was normal; the right showed a purulent, foul smelling empyema and several pulmonary abscesses (fig. 4). The dark field examination of the purulent fluid

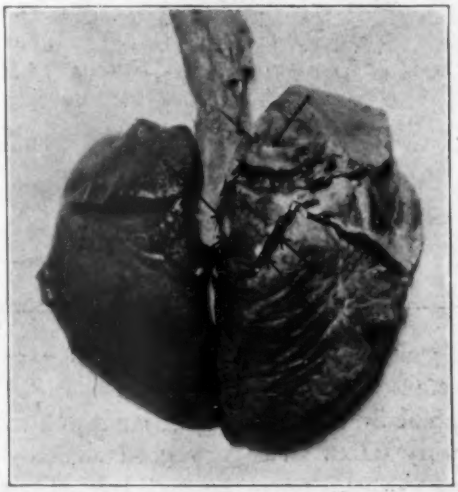

Fig. 4.—Lungs of a rabbit that died eight days after intratracheal injection of 1 cc. of pyorrhea material. At necropsy, empyema was found in the right pleural cavity, and several abscesses in the right lung, spirochetes, fusiform bacilli, anaerobic streptococci and vibrios were grown from the pulmonary lesions.

showed large numbers of spirochetes, fusiform bacilli and cocci. Cultures from the diseased lung gave an excellent mixed growth of spirochetes, fusiform bacilli and streptococci, which have now been propagated for eight generations. The results of this experiment are in accord with the observations of Kline,[6] who in 1923 produced pleuropulmonary gangrene in a rabbit by intrabronchial injection of material from a carious tooth.

Three dogs received intratracheal inoculations of pyorrhea material which was virulent for rabbits, guinea-pigs and mice, yet at necropsy the dogs presented no pulmonary lesions.

Two rabbits and eight guinea-pigs were given intravenous inoculations of pyorrhea material. Two of the guinea-pigs remained well and were normal at necropsy. Five of the guinea-pigs and one of the rabbits died in from forty-

6. Kline, B. S.: Experimental Gangrene, J. Infect. Dis. **32**:481 (June) 1923.

eight to ninety-six hours with extensive bilateral pneumonia. One guinea-pig and one rabbit presented widespread gangrenous and abscessed areas in both lungs. In all the lesions the fusospirochete-cocci combination of organisms was recovered.

COMMENT

Although a variety of organisms, including staphylococci, Friedländer bacilli or even colon bacilli, may occasionally produce lung abscess, it would seem, from experimental, pathologic and bacteriologic studies, that the common cause of this condition is the anaerobic group of organisms which is composed of (1) spirochetes of several morphologic types *(Treponema macrodentum, Treponema microdentum, Spirochaeta buccalis* and *Spirochaeta vincenti),* (2) fusiform bacilli, (3) streptococci and (4) vibrios.

Organisms Found at Necropsy in Fifty-Six Cases of Lung Abscess

Predisposing Condition	Number of Cases	Fusiform Bacilli	Cocci	Spirochetes	Vibrios
Spontaneous	22	22	21	15	16
Operation	10	10	9	9	3
Bronchiectasis	9	9	8	9	4
Pneumonia	7	7	7	7	2
Neoplasm	4	3	4	2	1
Tuberculosis	4	4	4	3	1
	56	55	53	45	27

It is probable that these organisms occasionally reach the lung by means of an infected embolus when the operative field is in an area in which they are habitually found, as in the gums and tonsils. However, the aspiration theory offers an equally good explanation for the pulmonary abscesses subsequent to operation on the upper respiratory tract, and a much more logical one for nonoperative pulmonary abscesses or those which follow a clean extrarespiratory operation.

CONCLUSIONS

Pulmonary abscesses have been produced in mice, guinea-pigs and rabbits by intratracheal inoculation of material scraped from the alveolar border of the teeth of patients suffering from moderately severe pyorrhea.

The same morphologic types of organisms have been recovered from these experimental abscesses as were found in both postoperative and nonoperative pulmonary abscesses in man.

Aspiration of infected material from the teeth and tonsils probably accounts for the greater number of cases of pulmonary abscess, although a small number may result from infected emboli from the upper respiratory passages.

ABSTRACT OF DISCUSSION

DR. WILLY MEYER, New York: Dr. Smith has made an important contribution to thoracic surgery, in particular to suppurative processes of the lung. His paper is divided into two parts: the present general discussion within the medical profession with reference to the etiology of lung abscess—Is it in the majority of cases due to aspiration, or is it due to embolism?—and, second, the treatment for the foul odor of the secretions of the lung by the intravenous introduction of neoarsphenamine. I am sure that when this discussion arose as to whether the cause of lung abscess was aspiration or embolism, the greater number who have followed patients of this type clinically for some time invariably have come to the conclusion that the majority of these cases are due to aspiration. One experience in particular deserves mentioning. Suppose a purely abdominal aseptic operation has been performed, under general anesthesia; there was perfect primary union; yet a lung abscess developed. Of course, that does not always happen, because pyorrhea is present. On the contrary, I believe that often vomiting is the cause—not pronounced, but slight vomiting—when the contents of the stomach have been brought up into the pharynx, from where they were aspirated. We all know, of course, that embolism may be the cause of lung abscesses, but, I think, in the minority of cases. Now we have heard this additional contribution by Dr. Smith, who has shown that dogs are not susceptible to this kind of infection; therefore, the failures seen in the dog. I certainly am one of those who firmly believe that the majority of lung abscesses following pneumonia and influenza are due to aspiration, and aspiration not only from the bronchial tree into the finest ramifications and into the lung parenchyma, but also from the pharynx subsequent to vomiting during general anesthesia. On account of lack of time, Dr. Smith did not discuss at length the treatment for the foul odor of the sputum in bronchiectasis and in many cases of lung abscess. Last summer I first heard of Dr. Smith's experiments from one of the representatives of the health commissioner of the State of New York in our district. Having followed this aspect for many years, I wrote to Dr. Smith immediately as to what he had seen in these cases. His answer came, and later he read a paper at the annual meeting of the State Medical Society in New York. As usual, on account of lack of time, his paper could not be dicussed. But here in our association we have that time. It was a most interesting observation that these partially anaerobic spirochetes and vibrios, which make these patients absolute outcasts, can be controlled even without operation by the administration of neoarsphenamine. Until this discovery was made only free incision and thorough ventilation of the bronchial tree could accomplish it. Of course, arsenic will not be effective in every case. Last fall a bronchictatic patient received intrabronchial treatment from Dr. Kernan, and in addition Dr. Smith's treatment; the odor disappeared completely. Later, the patient left the hospital for a few weeks, and when he returned there was a slight recurrence of the foul odor. Various reasons prevented giving the treatment again. After all I have heard and what I know about Dr. Smith's experience, I consider it important to know that the spirochetes which produce this smell are amenable to treatment with arsphenamine.

DR. F. T. LORD, Boston: Regarding the relation of abscess to embolism or aspiration, it must be a question whether the presence of this sort of flora in the sputum helps much in settling that particular question. It may be that these spirochetes and bacilli are simply part of the flora of the lower parts of the

respiratory tract in the presence of an infection. One aspect of these cases which always seems to me of importance in this argument is that there is a much greater incidence of abscess of the lung in winter than in summer. This is hard to explain on the basis of embolism and easy to explain on the basis of aspiration; in the winter the respiratory tract is much more prevalently affected. I do not understand Dr. Smith to state that he regards these organisms as the established cause of these abscesses. That would be difficult to prove without the isolation of the organism in pure culture and the production of abscesses by that pure culture. I have examined the expectoration of persons with pulmonary abscess for spirochetes and almost invariably found them. They are also present in empyema, secondary to abscess and in abscess pus obtained at operations on the chest wall; so that in almost all cases of abscess the presence of these organisms may be said to be established. However, it is difficult to ascribe chief importance to them in the etiology, because they are almost invariably mixed with other organisms.

Dr. A. V. S. Lambert, New York: Dr. Smith has accomplished something that many have been trying to do for a long time. It is interesting to compare Dr. Smith's procedure with that which others have employed. He allowed the injection to trickle in rather slowly over a fairly long period of deep anesthesia, as I understand it. This was ideal and obviously the thing to do, but it had not been done.

The organisms I was able to isolate apparently were identical with those which Dr. Smith found. I recovered the organisms from abscesses at the time of open operation through the chest wall. I subjected the animals to anesthesia and gave only one large injection into the trachea and then allowed the animal to recover from the anesthetic. I think that Dr. Smith's success lies in allowing a slow trickling in of the organism, reproducing intelligently the conditions present during operation. I failed to do this. The aspiration etiology is well established. This does not necessarily rule out all embolic cases. The ones which may have this factor as a possible etiologic factor are the cases which supervene a long time after anesthesia, usually as long as a week or ten days. It is at this time that emboli are likely to be dislodged, especially if infected. In my series of abscess cases, I saw a number that occurred from the seventh to the eleventh day after operation. In my experiments the only abscess which I was able to establish, using a pure culture of organisms obtained from lung abscesses which had been grown on a Noguchi medium, was in flea bites in the ear vein of a rabbit in which I had established a suppurative phlebitis.

Dr. Leo Eloesser, San Francisco: I should be inclined to suspect that the fact that in his experiments Dr. Smith laid bare the trachea and brought it up to the skin played a rôle in their success. It is interesting that he found first pneumonia, if I understand it correctly, and then the secondary abscess implanted on this primary pneumonia. Perhaps this might account for some of the questions Dr. Lambert has raised as to the rôle played by the spirochetes and the other invaders of the mouth. Are they merely implanted on a pneumonia, and do they cause gangrene secondarily, or are they a primary agent in causing the gangrene? Dr. Cutler's experiments are in a measure open to criticism because his method of tying off a vein, putting a small lead pellet in it and putting bacteria into this tied segment of vein is far from the conditions that cause the usual lung abscesses in human beings. It is notable, however, that by these methods he produced only a single lung abscess, and that the usual postoperative lung abscess is also single, whereas in pyemia with embolism abscesses are multiple. After the articles appeared from von Mueller's clinic

in Munich, who advocates the use of arsphenamine, I began using it in all abscess cases. Arsphenamine seems to clear up some of them partially, but not entirely, so that in some of these cases it has been necessary to operate later. Interested by these articles, I have made smears and tried to find what kind of spirochetes there were in the sputum. I have found spirochetes, just as Dr. Smith did, but I did not know what kind they were; I knew only that they were not syphilitic ones, because none of the patients bore evidence of syphilis.

Dr. Howard Lilienthal, New York: The matter of bacteriology in Dr. Smith's experiments is not as important as the fact that he has shown that reproducing the conditions of operations on human beings may produce lung abscesses in animals.

Dr. Nathan W. Green, New York: In Dr. Smith's paper I have failed to note that he has entirely reproduced the conditions that occur in some of our operative cases in which postoperative pneumonia develops and, perhaps following it, a lung abscess. That is, I did not hear him say that he had made any abdominal incision in any of these cases in consequence of which the coughing reflex would become somewhat inhibited due to the discomfort. He spoke of one clear case in which the guinea-pig coughed out the material through his nose. This was striking, but I should like to ask him whether he has simulated the conditions in abdominal operations when in addition to the anesthesia and the aspiration of material the coughing reflex has been impaired due to the laparotomy.

Dr. David T. Smith, Ray Brook, N. Y.: I will answer the last question first. I did not open the abdomen of any of the guinea-pigs because I did not want to introduce any more complicating factors than necessary. In regard to Dr. Meyer's remark about the odor: Noguchi found that pure cultures of *Treponema microdentum* gave off a foul odor. I have not been able to isolate pure cultures as yet, but mixed cultures of spirochetes, fusiform bacilli and anaerobic cocci give a foul odor when grown in pleural fluid, and this odor is identical with that in lung abscess. Dr. Lord asked whether these organisms were merely secondary to any chronic pulmonary infection. I investigated 150 cases of uncomplicated pulmonary tuberculosis, and although there was secondary infection with streptococci, pneumococci and influenza bacilli, the anaerobic group of organisms was not present. Of about 300 patients we have studied in the New York State Hospital for Incipient Tuberculosis, only three had both spirochetes and tubercle bacilli in the sputum. In a study that is being carried on now it is hoped to isolate each and every one of the organisms present around the teeth and then inject them into animals one by one until the combination necessary for the production of this disease is found. I know of Dr. Lord's work on the winter incidence of abscess. It is undoubtedly an important contribution. But it occurs to me that increased sneezing and secretion associated with these infections may tend to cause more people to aspirate anaerobic organisms in winter. In regard to Dr. Lambert's question, when I introduce this material into the lungs of an animal and an animal dies in from twenty-four to ninety-six hours, I never see abscesses; I see pneumonia. I have not seen an abscess manifest itself before eight days after the introduction of this material into the lung, and generally it is ten or twelve days before definite abscess occurs. I cannot say that it is proved, but it is indicated that abscess goes through this pneumonic stage before breaking down.

TRANSPHRENIC INFECTION

REPORT OF TEN CASES *

HOWARD L. BEYE, M.D.
IOWA CITY

The diaphragm presents a striking barrier to the spread of infection from the pleural cavity. Extension through it in cases of empyema or lung abscess is remarkably infrequent. In a series of 190 cases of acute and chronic empyemas in the surgical service of the University Hospital since Jan. 1, 1915, infection has passed through the diaphragm in only a single instance (case 10), and in this patient the diaphragm was traumatized at operation.

In infections originating below and in contact with the diaphragm, however, the likelihood of the process passing upward to involve the pleural cavity or lung parenchyma is distinct. In our series of twenty-four cases of subphrenic abscess, a transphrenic infection has taken place in eight spontaneously. In another, the pleura was opened in draining the abscess, but already there was such a marked and sudden reaction in the pleura that infection of it was imminent (case 8).

This is explainable on the basis of the lymphatic drainage of the diaphragm. The latter is supplied with a rich network of lymph vessels which lie on the thoracic and abdominal surfaces of the muscle, penetrate it freely, and drain into systems of nodes which lie on the thoracic side. Probably in most cases extension of infection upward is purely lymphatic at the onset.

An uncomplicated subphrenic abscess will often present a clinical problem which is difficult to interpret and to treat. This is likely to be greatly increased when the condition is complicated by an extension of the infection above the diaphragm to pleural space or lung.

ONSET AND CLINICAL COURSE

In this series of ten cases, three patients developed subphrenic infection as a complication of an acute attack of appendicitis. A fourth had been operated on for appendicitis two years before, and at necropsy an abscess was found extending from the diaphragm to the pelvis with a perforation into the cecum. Four patients probably had acute perforations of peptic ulcers. One patient had a perinephric infection. The tenth case was originally one of acute empyema.

Spread of the infection through the diaphragm took place insidiously in seven of the cases. In one patient a subphrenic abscess formed as a

* From the Department of Surgery, University of Iowa College of Medicine.

complication following the removal of a gangrenous appendix, remained latent for a year and then began to produce symptoms referable to the chest, culminating in rupture of the abscess into a bronchus. In another, an abscess drained into the colon and into a bronchus with the formation of a broncho-intestinal fistula, which persisted for three years without producing striking symptoms. In the only case in which infection traveled from pleura to peritoneum, the patient was discharged as cured following drainage of the empyema, and the subphrenic infection manifested itself subsequently.

The onset of the transphrenic infection was acute in three cases, two of which followed the acute perforation of peptic ulcer. In one of these about the fourteenth day what was taken to be a hypostatic pneumonia suddenly developed with cyanosis and rapid respirations. The other patient, who was under close observation in our service, on the twelfth day suddenly developed a massive exudate in the left pleural cavity with rapid respirations. Prior to that repeated examination of the chest had been negative for fluid.

The insidiousness of the onset in most of the cases is explained by a localizing pleuritis that preceded the gross infection of pleura or lung. In two cases, the pleural space was completely obliterated in the region of the diaphragm, and infection had entered the lung parenchyma. In another an empyema cavity was found divided into pockets by long bands of adhesions passing between diaphragm and visceral pleura, suggesting that an obliterative pleuritis had preceded.

Bronchial drainage was spontaneously established in four cases: two in which empyema developed secondary to the subphrenic infection, and two in which the infection was directly into the lung parenchyma. In the latter cases, there was undoubtedly a gross break in the diaphragm with direct communication between the subphrenic abscess and the bronchus. In one of these cases a fistula developed between the bronchus and the colon. In only one of the four cases did the bronchial fistula heal spontaneously.

A gross defect in the diaphragm was demonstrated at operation or necropsy in four cases, excluding the patient whose diaphragm was incised at the time of operation for empyema. In three of these, the sinus was near the lateral margin of the diaphragm close to the junction between the latter and the chest wall, and in each the defect would admit the tip of the index finger. In the fourth case, the opening through the diaphragm was at the junction, on the left, between the diaphragm and its vertebral attachment. In two more cases, there was definite clinical evidence of a gross communication between the infraphrenic and the supraphrenic infection. In only three of the ten cases, therefore, the infection may have traveled entirely by way of the lymphatics without gross perforation of the diaphragm.

DIAGNOSIS

A carefully taken history with special stress laid on etiology is of the greatest importance. In case 2, failure to observe this led to an inaccurate interpretation of the observations. In the chronic or latent cases with the history of an acute abdominal insult, such as perforation of a peptic ulcer or acute appendicitis, one should always suspect the presence of a subphrenic infection even through the symptoms are referable to the thorax.

The roentgen-ray study must be thorough. One may easily overlook evidence of a subphrenic abscess when concentrating attention on the intrathoracic pathologic condition. In case 2, the roentgenographic demonstration of such an abscess was neglected for weeks because of the obvious evidence of a gross pathologic condition in the lung or pleura. The roentgen ray may be misleading, however, if depended on too much. Figure 15 was the evidence for a diagnosis of subphrenic abscess, secondary to a lung infection. This proved to be an empyema with no involvement below the diaphragm. Lung mapping will help in certain cases. In case 1, it was a great aid in localizing the intrathoracic course of the intestinal-bronchial fistula. In case 2, it demonstrated a lung abscess as distinct from the subphrenic abscess beneath it.

Tenderness under the costal margin and in the flank, with rigidity of the wall, cannot be passed over too lightly in cases in which the pathologic condition is seemingly all above the diaphragm.

TREATMENT

In this series, there were two cases in which drainage of an empyema led to an apparent cure of the subphrenic infection. In each, there was a gross defect in the diaphragm connecting the two areas. In a third, drainage of the empyema had no influence on the subphrenic infection.

In one case, drainage of a subphrenic abscess did not prevent the later development of an empyema. In one, the drainage of the subphrenic abscess has caused almost complete relief of symptoms referable to a lung abscess, with possibility of cure. In another, drainage of the subphrenic abscess was followed by death. In this case, the pleura was not grossly infected and was accidently opened.

In two cases, a subphrenic abscess and communicating empyema were both drained. One of these patients recovered. The other died, and necropsy disclosed an extensive abscess from diaphragm to pelvis.

In one case drainage of an enormous subphrenic abscess had no great effect in clearing up the intrathoracic infection because the latter communicated with the large bowel and was not in intimate relation with the abscess at the time of operation.

In one case, drainage of an empyema did not prevent the later development of a subphrenic abscess. However, the diaphragm had been opened at the first operation, although at the point opened the empyema was not entered.

REPORT OF CASES

CASE 1.—*History.*—A woman, aged 23, entered the University Hospital, April 8, 1926, stating that three years before she had had an acute attack of appendicitis with a spreading, diffuse peritonitis. She had been operated on about the seventh day; the appendix had been removed and an abscess drained. She had had a stormy postoperative course and a fecal fistula had developed about the tenth day. After two months has passed, she had begun to have some pain in the left upper quadrant of the abdomen, associated with a cough which produced a moderate amount of sputum without odor. At one time the sputum contained blood. She continued to have fever and did not gain. She was treated for pulmonary tuberculosis.

After nine months the fecal fistula had been closed by operation; following this she had gained slowly in weight and strength during the next year. During this period she occasionally had spells of coughing, raising nearly a cupful of odorless pus.

About one year before admission, backache had developed over the lower lumbar region. This had bothered her, especially in bending, and had been a persistent symptom since its onset.

Four months before she had noted a firm mass in the left side of the abdomen. This was not tender. It had gradually increased in size and had produced a visible prominence. Recently, she had noted a swelling in the left side of the back, and this was moderately tender. She had had only slight pain in the region of the swellings.

The coughing spells had increased in frequency to every four or five days, but the sputum raised was about the same, from 2 to 4 ounces (59.2 to 118.4 cc.) daily. She had had an afternoon fever of 99 to 100. Her general health had been good and she weighed more than she ever had.

Examination.—The chest was well developed and expansion was good, with a suggestion of limitation on the left. On the left side posteriorly, the lower limit of resonance was about 2 inches (5 cm.) higher than on the right. Above this the breath sounds were clear and unaltered, and fremitus was normally transmitted. Below this there were flatness and absence of breath sounds.

The right side was unchanged, and the heart was not displaced.

There were visible enlargement and a palpable mass in the left side of the abdomen from the inguinal region to the ribs. This produced a distinct bulging in the flank, and this was especially marked posteriorly between the twelfth rib and the iliac crest. Here there was moderately marked tenderness. The mass in front was slightly tender.

Roentgenographic and fluoroscopic examination (fig. 1) showed that the left side of the diaphragm was about 2 inches (5 cm.) higher than the right; it was well outlined, regular and dome shaped. There was no excursion on respiration. The right side of the diaphragm was normal in every way.

An accumulation of air was seen below the left side of the diaphragm, bounded below by a fluid level. This could be thrown into waves by shaking the patient. To rule out the stomach, barium was ingested, and it passed mesial to and below the visible fluid level. When the patient was placed horizontally, the barium could not be made to encroach on the position of the fluid.

The hemoglobin content was 75 per cent; the red blood cells totaled 4,159,000, and the white blood cells 14,300.

Urinalysis was essentially negative.

Operation and Course.—An operation was performed, April 9, under ethylene anesthesia. A left muscle splitting incision below the iliac crest opened into an abscess containing more than 2 quarts (1,892 cc.) of brownish yellow pus, moderately thin, odorless and containing small clumps of fibrin. A counter drain was made in the flank. A pure culture of *Staphylococcus aureus* was grown from the pus. Drainage from the cavity persisted, with no tendency for the latter to heal. The cough and sputum were not relieved and an irregular fever persisted,

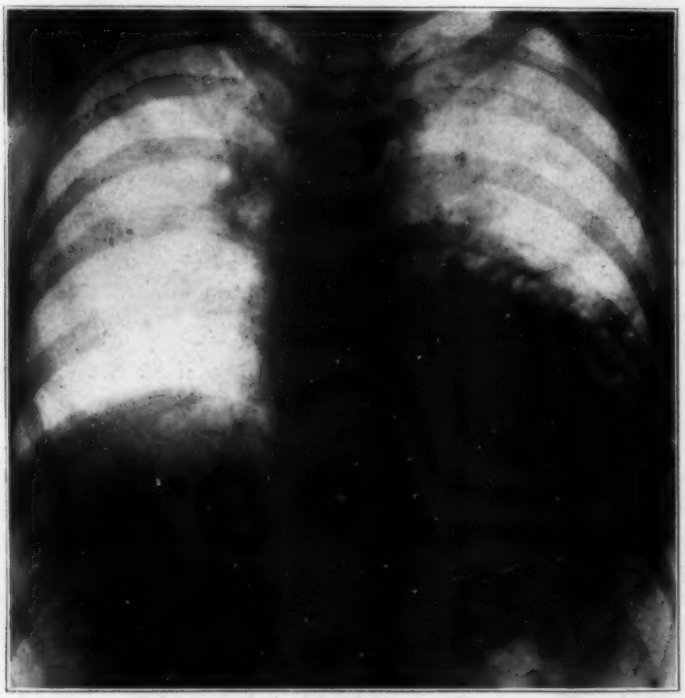

Fig. 1 (case 1).—Lung mapping with iodized oil, showing the localized accumulation in the angle between the diaphragm and the spine at the level of the tenth rib. When a barium enema was given, a narrow tortuous tract became outlined; this began in the region of the splenic flexure and passed toward the area seen in this view. When this point was reached by the barium the patient had a violet paroxysm of coughing and raised some of the barium suspension. It was not possible to get roentgenographic evidence of the tract because of the cough.

together with a leukocytosis around 15,000. Irrigation of the cavity with surgical solution of chlorinated soda (Dakin's solution) at no time induced coughing.

Lung mapping was done by Dr. L. W. Dean, and Dr. T. F. Baxter reported on the roentgen-ray examination: Fluoroscopic examination was made after the injection of the lungs bilaterally with iodized oil, 40 per cent. The base of the right lung showed a reasonably large amount of iodized oil with nothing unusual

present. The right side of the diaphragm was normal. The greater portion of the iodized oil was in the left lung. The diaphragm movement on this side was limited, especially near its center. The iodized oil was distributed in the left base in a manner that suggested some defect in this area. It looked as though some of the iodized oil had trickled downward in the region of the left upper quadrant of the abdomen, suggesting the possibility of some communication through this side of the diaphragm. A mouthful or two of barium mixture was given to outline temporarily the cardiac end of the stomach and to assist in the localization in the left side of the diaphragm. The roentgenograms confirmed the fluoroscopic observations. The distribution of the iodized oil in the base of the left lung suggested the possibility of a defect in this area somewhat toward the median

Fig. 2 (case 2).—Appearance four months after drainage of the subphrenic abscess. A mass of iodized oil remains above the diaphragm. The cough and sputum were completely relieved.

line, beneath which there was an irregular area of diminished density, probably below the diaphragm, suggesting strongly a communication between the base of the left lung and the subdiaphragmatic area.

The patient gradually improved in a general way and was sent home with the cavity draining. She returned to the hospital because of the sudden development of a high fever and chill.

She stated that one noon she had had a lunch consisting of red raspberries. The following afternoon she had suddenly had a coughing spell and had coughed up considerable sputum which contained unmistakable raspberry seeds. On further questioning, she said that during the last year on several occasions she had coughed up material which she had taken to be shreds of oatmeal and pieces of vegetable. She also stated that many times she had belched up a foul smelling

gas "through the lung." She said that about a year before when given an enema by her mother the fluid almost strangled her immediately on its being injected into the bowel.

With this additional history, the presence of a communication between the intestinal tract and the lung was suspected, and fluoroscopic examination, using a barium enema, was attempted.

Fluoroscopic Examination.—The barium enema passed easily to fill the entire large bowel. Shortly after the bowel was well filled, a narrow tortuous tract was seen to lead off from the region of the splenic flexure, upward and inward, to the angle formed by the diaphragm and the spine. Just as the barium reached this angle the patient had a violent spell of coughing and began to raise the

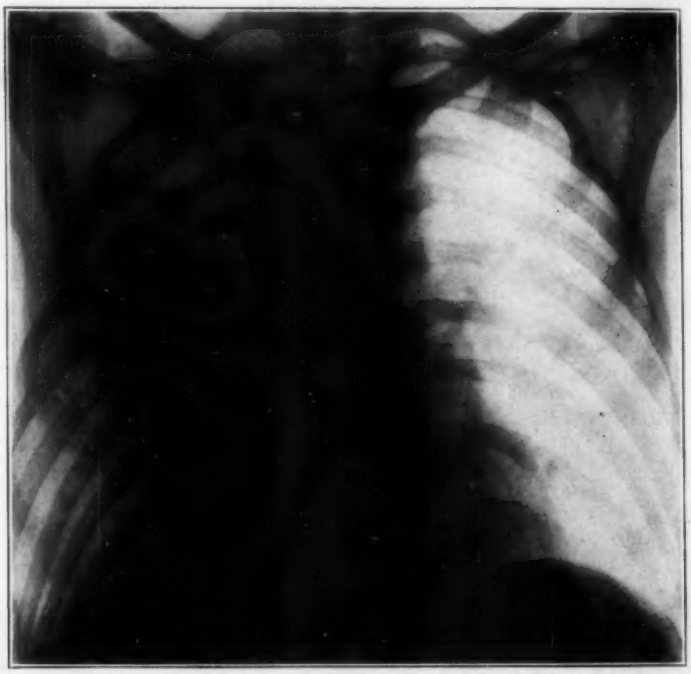

Fig. 3 (case 6).—Rapid development of an extensive empyema through a gross defect in the diaphragm.

barium suspension. She sat up abruptly, and whenever an attempt was made to have her recline, another violent paroxysm was brought on. It was impossible to get roentgenographic evidence of this tract. Roentgenograms of the chest (fig. 3) showed the iodized oil still present in the lung with a discrete accumulation between the ninth and tenth ribs close to the spine, suggestive of the sinus tract, which was demonstrated from below by barium enema.

Second Operation and Course.—A second operation was performed, July 20, under ethylene anesthesia. With the patient lying on the right side, a long incision was made through which all of the tenth rib and several inches of the ninth were resected. The peritoneum was opened for exploration. There were remarkably few adhesions in the left upper quadrant. The transverse and descending portions of the colon were mobile. Just distal to the splenic flexure

was a sinus tract which passed from the posterior aspect of the bowel upward and mesially. It seemed to pass behind the peritoneum along the posterior margin of the spleen. Posteriorly, in the angle close to the spine the tract was again found. Here it passed through the diaphragm and entered adherent lung. The pleural cavity was obliterated. The tract was cut across and found to open into a lung abscess which would hold about 1 ounce (30 cc.). Into this cavity three distinct bronchi opened. A probe was passed into one of these and could be passed upward for several inches.

The peritoneum was closed without drainage. The long incision was closed in layers providing tube drainage to the lung cavity and region of the divided fistula.

The patient has had a rather sustained febrile course. The cough has been definitely less. Evidence of patency of the fecal fistula has persisted. Fecal material is occasionally found in the dressings of the posterior wound. Drainage from the lung abscess is moderate but the bronchial fistula persists. The patient is improving generally, and the temperature is gradually approaching normal. She is still in the hospital.

An acute suppurative appendicitis with diffuse peritonitis was followed by a subphrenic abscess on the left side. This ultimately drained spontaneously by two routes; into the large bowel and through the diaphragm into a bronchus, with a resulting broncho-intestinal fistula. The large subphrenic abscess present on admission to this hospital seemed to be entirely independent of the communication between the bowel and the lung. At no time did irrigation of it induce coughing.

Case 2.—*History.*—A man, aged 44, entered the University Hospital, March 24, 1926, stating that in June, 1925, he began to lose weight and strength and have fever and sweats. He developed a slight cough. After a month he suddenly coughed up a large amount of foul sputum, and following this the cough had been more or less constantly productive of a foul tasting and smelling sputum. Serous fluid was found in the right pleural cavity and withdrawn by a needle. A diagnosis of pulmonary tuberculosis was made, and he was sent to the State Tuberculosis Sanitarium. Here, more than forty sputum examinations were negative for tubercle bacilli, and he was transferred to the University Hospital to the otolaryngologic service for lung mapping.

The past medical history was negative except for appendectomy in 1923. The patient left the hospital in three weeks apparently well.

Examination.—The patient was greatly emaciated, and had frequent coughing spells, producing a yellow-green, foul smelling, purulent sputum. There were signs of fluid below the level of the angle of the scapula on the right side. The heart was displaced somewhat to the left.

There was slight rigidity along the costal margin on both sides of the abdomen, especially on the right. There was slight tenderness on firm palpation under the right costal margin.

The temperature ranged around normal, with an occasional sharp rise. The leukocyte count was 8,900. The sputum was foul smelling and thick; there were no elastic fibers.

A roentgenogram of the chest (fig. 4) showed a dense shadow on the right from the midscapula to the diaphragm. The latter was obscured. The heart

shadow was displaced somewhat to the left. Lung mapping was done by Dr. L. W. Dean, which demonstrated an accumulation of iodized oil, 40 per cent, in a large cavity at the end of the right terminal bronchus. The diagnosis was lung abscess with pleural effusion or empyema with bronchial communication.

Operation and Course.—An operation was performed, March 25, 1926, under ethylene anesthesia. Resection of 3 inches (7.6 cm.) of the right ninth rib posteriorly was performed. The pleural cavity contained a large amount of clear

Fig. 4 (case 7).—Appearance twenty days after an acute perforation of a peptic ulcer. There is gas under the left side of the diaphragm and slight haziness above on the right.

serous fluid and air. The lung was partially collapsed. The base of the lower lobe was tightly fixed to the diaphragm in the region of the maximum elevation of the diaphragm. The remainder of the lobe was collapsed away from the chest wall. Palpation of the lobe was not satisfactory because of the small incision, but with the finger-tips the impression was gained that it was abnormally firm.

The incision was securely closed in layers to make an air-tight repair. The postoperative course was uneventful.

Further roentgenographic study in the light of the observations made at operation gave a clue to the real condition. What had been interpreted to be the upper level of an empyema cavity or indurated lung area was found to be the diaphragm (fig. 5).

A roentgenogram was made, using the portable unit, with the patient in the sitting position. This demonstrated the presence of a cavity below the diaphragm with a well defined fluid level and containing air, a pyopneumothorax subphrenica (fig. 6). Above this was a dense shadow in the lower lobe in the area that had been found so tightly adherent to the diaphragm at the time of operation.

Fig. 5 (case 7).—Appearance eight months after the development of transphrenic infection. This proved to be a well localized empyema.

The patient was now more closely questioned regarding his operation for appendicitis, and he gave the following additional data: The appendix had been gangrenous and perforated when removed, but the incision had been closed without drainage. A few days after returning home, he had had some pain along the right costal margin and had been forced to go to bed. The foot of the bed had been kept elevated for two weeks. He had been in bed for two months and had had fever during this period, but he had finally recovered, and after several months had been able to go back to work. He had been in good condition until the onset of the present trouble, an interval of more than a year.

The last diagnosis was lung abscess and subphrenic abscess.

Second Operation and Course.—A second operation was performed, March 30, 1926, under nitrous oxide anesthesia. An incision in the sixth interspace anteriorly opened into an abscess lying below the diaphragm containing more than a quart (946 cc.) of foul smelling pus, gas and clumps of spongy grayish black tissue, suggesting gangrenous lung. A defect in the diaphragm could not be felt through

Fig. 6.—Roentgenogram that led to the erroneous diagnosis of a subphrenic infection secondary to a pulmonary infection. This proved to be an empyema. The dark shadow is solid lung with bronchiectasis. A bronchiectatic cavity had perforated on the diaphragmatic side of the lung, with the resultant unusual empyema. The diaphragm was displaced markedly downward but was intact.

the small incision. Below, the liver was adherent to the costal margin, thus walling off the cavity from the general cavity. An additional incision was made inferiorly to obtain dependent drainage.

Recovery was uneventful with almost immediate relief from fever, cough and sputum. Drainage from the cavity gradually decreased. Four months after operation, a draining cavity persisted below the diaphragm but there was only slight discharge. Irrigation with surgical solution of chlorinated soda (Dakin's solution) did not induce coughing. The patient had gained many pounds in weight and was able to do his daily work. The cough was completely relieved. Roentgen-ray examination (fig. 7) four months after operation seemed to show a cavity in the lower lobe still containing considerable iodized oil.

A subphrenic abscess developed as a late complication following the removal of a gangrenous appendix. This became latent after a period of several months' activity, and after a year of quiescence, became active and extended through the diaphragm to form a lung abscess and rupture into a bronchus.

In this case an incomplete initial history obscured the diagnosis.

CASE 3.—*History.*—A man, aged 48, entered the University Hospital, April 15, 1925, stating that in May, 1924, he had suddenly developed a sharp pain in the right lower quadrant of the abdomen, with some fever and nausea. A diagnosis of appendicitis had been made, but the operation had been deferred. After an illness of three weeks, operation had been advised, but the patient had developed what was thought to be pneumonia, and for the next four weeks he had had an afternoon temperature of 103. He had had no cough or pain in the chest. Three days after returning home, he had developed a severe paroxysm of coughing one night and had raised more than a quart (946 cc.) of foul smelling pus. Following this, he had begun to improve. Two months later, an abscess had developed in the chest wall at the base of the right axilla, which had been drained by rib resection. A month later a cellulitis had developed in this area and another rib resection had been performed. These wounds had never healed completely, and discharged a thin seropurulent exudate. A few weeks later he had developed pleurisy on the left side, which had lasted for a few days. He had lost a great deal of weight and strength and had had a febrile course since the onset.

The past medical history was essentially negative. He said that he had had no symptoms suggesting peptic ulcer. He had had double pneumonia at 19, with complete recovery.

Examination.—The patient was emaciated and weak. There was considerable retraction of the right side of the chest. At the base of the right axilla and posteriorly were several operative scars with two draining sinuses. On this side there was flattening of the percussion note from the eighth rib down, in the axilla and posteriorly, with absence of breath sounds. There was some impairment to percussion on the left side in the axilla.

The right rectus muscle was rigid, and tenderness was diffusely present in the right upper quadrant of the abdomen and in the loin.

The hemoglobin content was 75 per cent; the red cells totaled 3,840,000; the leukocytes, 8,200. Urinalysis was negative.

Roentgenographic study of the chest showed complete limitation of excursion of the diaphragm on the right and a dense shadow from the eighth rib to the diaphragm. The left side of the diaphragm had free excursion. The diagnosis was chronic empyema.

Operation and Course.—An operation was performed, April 16, 1925, under ethylene anesthesia. The sinus openings converged to an extensive involvement of the chest wall from the ninth to the eleventh ribs, inclusive. These ribs as well as the muscles between them, were infiltrated with a thick caseous pus. In the upper portion of the wound there was a chronic empyema cavity the size of a hen's egg, well defined and containing no bronchial opening. The involved ribs were resected and the wound packed with iodoform gauze.

The patient's condition was fairly satisfactory until the fourteenth day, when the patient contracted pharyngeal diphtheria and was transferred to the isolation hospital. Here, massive doses of antidiphtheric serum were given. The wound of the chest wall became covered with a thin grayish membrane, from specimens of which cultures of a diphtheric bacillus were grown. The patient died on the eighteenth day after operation.

Necropsy.—This disclosed an old infectious process between the right lobe of the liver and the diaphragm, consisting of fibrous tissue permeated with small abscesses. The omentum was adherent to the liver and gallbladder, and in it were numerous small abscesses. The appendix appeared normal. This extensive area lay immediately below the involvement of the chest wall. Both lungs were adherent at their bases. The bronchi were dilated and contained pus.

This patient probably had an initial acute appendicitis with subphrenic infection. The latter extended through the diaphragm to produce an empyema and later through the chest wall to involve the ribs and soft tissues. The empyema subsequently emptied into a bronchus with partial relief, and operative drainage of the empyema and chest wall further localized the process in the pleura. The observation of an uninvolved appendix at necropsy is not incompatible with this explanation of the pathologic course, since a year had elapsed following the acute onset.

Case 4.—*History.*—A woman, aged 24, entered the University Hospital, May 21, 1924, stating that eight weeks before she had developed malaise, aching and diarrhea. She also had had a chill and had been in bed ever since with a high temperature and great prostration. For the last two days she had had a little cough. At this time she had been told by a physician that the right lung was solid. She had lost a great deal of weight.

The social and family histories were negative. She had never had any respiratory trouble until the present illness. The appendix had been removed in 1922. There had been no history of any complication following this.

Examination.—The patient was slight. The general examination was negative, but there was marked fulness in the lower portion of the right side of the chest anteriorly. Expansion was poor on both sides. The percussion note was greatly impaired from the third rib downward on the right. The breath sounds were suppressed. The heart was displaced to the left. There was a well healed McBurney's scar. There was evident fulness just under the right costal margin, and this was somewhat tender. There was a marked tenderness in the angle between the twelfth rib and the spine posteriorly.

The hemoglobin content was 60 per cent. The red cells totaled 3,500,000, and the white cells 9,800. The urine was normal except for albumin 2. A roentgenogram showed a diffuse shadow on the right side of the chest from the fifth rib posteriorly to the diaphragm. The diagnosis was empyema and subdiaphragmatic abscess.

Operation.—An operation was performed, May 21, 1924, procaine hydrochloride infiltration being used. A subperiosteal resection of the ninth rib was made, opening into an empyema containing a thick, grayish yellow pus streaked with blood. The cavity was flat, and between the diaphragm and the visceral pleura and between the visceral pleura and the parietal pleura were drawn out adhesions, which tended to divide the cavity into various pockets. No gross break in that portion of the diaphragm which could be palpated could be made out. Drainage of the cavity was made by tube. The postoperative course was satisfactory.

Second Operation and Course.—A second operation was performed, May 27, 1924, under procaine hydrochloride infiltration. Through the seventh intercostal space anteriorly a large abscess cavity lying between the liver and diaphragm was entered. The pus was thick. The diaphragm lay at such a high level that a gross defect in its surface could not be palpated.

After operation the patient continued to run a fairly high, irregular temperature, with a rapid pulse, and she gradually weakened. The signs and symptoms of pleurisy developed on the left side and, later, a suppurative parotitis. Death occurred on the thirty-first day following the drainage of the empyema.

Necropsy.—There was a large subdiaphragmatic abscess on the right side which passed behind the liver, where it extended through a sinus in the diaphragm to open into the right pleural cavity. It also extended downward behind the peritoneum, throwing the ascending colon forward to perforate into the pelvis below the cecum. Here it was in contact with the cecum, and the latter was perforated in two or three places. In the liver were found several abscesses, varying in size from a few millimeters to centimeters. The left pleura contained 2,500 cc. of a serous exudate. Mural thrombi of the inferior vena cava and right iliac vein were also present.

It is impossible to state accurately the origin of this patient's condition, but with the history of onset with diarrhea together with the symptoms of a profound infection, the chances are that an abdominal infection was the initial trouble. What the relation was between this and the operation for appendicitis may be only conjectured. The infection traveled upward behind the colon to the subphrenic region and subsequently broke through the diaphragm to produce an empyema. That there was an obliterative type of pleuritis preceding the gross infection, with the later production of purulent exudate, is strongly suggested by the type of empyema found at operation.

CASE 5.—*History.*—A man, aged 65, seen in consultation, Jan. 11, 1926, stated that about five weeks before he had been suddenly seized with acute pain in the upper part of the abdomen associated with severe shock. The upper part of the abdomen had been rigid, especially in the epigastrium, and tenderness had been diffuse. The patient had vomited. He had had no fever but a leukocytosis of 22,000. About twelve hours after the onset, jaundice had become manifest. This had persisted as a lemon yellow tinge to the sclera and skin. The condition was so desperate that operation had been withheld. He had finally improved, although tenderness and rigidity had persisted in the epigastrium and along the right costal margin. About three weeks before he had developed what had been taken to be hypostatic pneumonia. He had become cyanotic and the respirations rapid. These symptoms had gradually improved.

Five months before the onset of this illness, he had had a severe attack of pain in the epigastrium for a few hours, which had subsided completely. He had always complained of a good deal of belching of gas and had to be careful of his diet because of distress associated with the taking of food.

Examination.—The patient had considerable tenderness in the epigastrium and under the right costal margin, and both rectus muscles were held fairly rigid. There was free fluid demonstrable in the general peritoneal cavity. Tenderness in the flank just below the twelfth rib was definite but not marked, and continued forward to merge with the anterior tenderness. There was dulness over the lower two-thirds on the right side of the chest behind and in the axilla. Over this area the breath sounds were greatly diminished. The heart was displaced to the left. The roentgenogram of the chest showed a diffuse shadow on the right, merging with the diaphragm. The heart was displaced to the left. The diagnosis was perforated peptic ulcer, with subphrenic abscess and empyema.

Operation and Course.—The patient was operated on, Jan. 11, 1926, under procaine hydrochloride anesthesia. Aspiration in the posterior-axillary line in the seventh interspace revealed a bile stained fluid containing pus. Rib resection at this level opened into an empyema. About a gallon of fluid escaped. This was heavily bile stained at first; later it became a muddy orange red and contained heavy clumps of fibrin. It had the odor of vomitus. The cavity was drained with large tubes. A pure culture of *Bacillus coli* was grown from the pus. Drainage was profuse for the first few hours, following which it became scant. There was a decided improvement in the patient's general condition, and the tenderness and rigidity in the abdomen cleared up rapidly. When seen five weeks after the operation, there was a small sinus persisting in the wound. On physical examination, it seemed that the lung had expanded to fill the pleural cavity and the breath sounds came through clearly. Tenderness was practically gone, although it was present to a slight degree on palpation along the costal margin just to the right of the midline. The patient has since apparently completely recovered.

In this case there was acute perforation of a peptic ulcer with development of a subphrenic abscess. This perforated grossly through the diaphragm to form an empyema. Drainage of the latter established sufficient drainage of the subphrenic infection to determine a cure.

CASE 6.—*History.*—A man, aged 26, entered the University Hospital, July 29, 1926, stating that in February he had been suddenly seized with a severe abdominal pain that made him walk the floor. He had been ill for six weeks following this with high fever and marked constipation. Shortly after recovery from this, he had developed pain in the right lower quadrant of the abdomen, and had had his appendix removed. He had been fairly well for a month, when pain had recurred in the inguinal region and in the region of the appendectomy scar, and later in the back above the iliac crest. This had been aggravated by extending the leg. He had had irregular fever since the onset and had lost 50 pounds (22.7 Kg.) in weight and much strength. About three weeks before admission he had developed a cough which was not productive.

The patient had had influenza in 1919. His appetite had been irregular for years, and certain foods, such as cabbage, caused severe epigastric pain. Last summer he had had a diarrhea with stools daily for some time, but with recovery.

He also had had frequency of urination for a time, voiding hourly during the day and from three to four times at night. He had passed no blood, pus or stones.

Examination.—The patient was greatly emaciated. The chest was long and thin. Expansion was free and equal. The lungs were clear to percussion and auscultation. Litten's sign was present on both sides. The heart was normal in size and position. There was a well healed lower right rectus scar and some right rectus rigidity. Tenderness was present on deep palpation over the entire right rectus, laterally to the ilium and posteriorly between the iliac crest and the twelfth rib. The edge of the liver was four fingerbreadths below the zyphoid. The results of rectal examination were negative except for some hemorrhoidal masses. The temperature ranged between 99 and 101.5.

The hemoglobin content was 80 per cent. The red cells totaled 4,520,000, and the leukocytes, 15,400. The urine showed nothing pathologic. A roentgenogram of the chest (fig. 8) showed the outline of the diaphragm normal on both sides. There was no evidence of fluid in either pleural cavity. The markings of the lungs were clear.

Cystoscopy was performed by Dr. R. J. Crary. Injection of 7 cc. of sterile water into the pelvis of the right kidney caused marked distress, identical with the pain that had been present in the lumbar region. A pyelogram showed a normal pelvis. Urine drawn by ureteral catheter was negative for infection.

The diagnosis was a lumbar abscess on the right side.

Operation and Course.—An operation was performed, Aug. 12, 1926, by Dr. F. R. Peterson, under ethylene anesthesia. An incision made between the twelfth rib and the iliac crest opened into an abscess containing about 6 ounces (178 cc.) of thick, foul smelling pus. In the bottom of this was felt the tip of a necrotic transverse process which had partially sequestrated. A counter incision was made just anterior to the iliac crest. The abscess seemed well localized and did not extend upward to the level of the diaphragm. A pure culture of a nonhemolytic streptococcus was grown from the pus.

The patient had marked relief from pain. Drainage was profuse. The temperature remained irregularly elevated. On the tenth day the patient had some pain in the right side of the chest, and a coarse friction could be heard at the base. Two days later, there was dulness from the level of the scapula to the diaphragm, and roentgenographic examination of the chest showed flattening of the diaphragm and a diffuse shadow in the lower portion of the right side of the chest (fig. 9). On the fifteenth day after operation there were definite signs of fluid.

Second Operation and Course.—A second operation was performed, Aug. 27, 1926, under ethylene anesthesia. Pus was found by aspiration and a segment of the eighth rib was resected posteriorly. Over 1,000 cc. of a foul smelling, frank pus was evacuated from the pleural cavity. A defect was palpated in the outer, posterior quadrant of the diaphragm about an inch (2.5 cm.) from the chest wall, which readily admitted the index finger. Tube drainage was instituted. A pure culture of a hemolytic streptococcus was grown from the pus.

A profuse foul smelling pus drained from the incision for three days, with gradual subsidence. It was noted that when the patient was turned on his right side during dressing there would be a sudden gush of pus. The empyema had been thoroughly emptied at the time of operation. Irrigation of the cavity produced no cough reflex. No communication could be demonstrated between

the empyema and the lumbar abscess by the fluid injected. The empyema cavity had decreased in size markedly and the temperature had fallen to normal. The patient was still under observation.

This patient probably had had an acute perforation of a peptic ulcer, or possibly an acute suppurative appendicitis. Subsequently, a subphrenic abscess had developed, a portion of which gravitated into the flank and became independent of a portion between the liver and the diaphragm. The former was drained by operation. The latter ruptured through the diaphragm to produce an empyema. Drainage of the empyema has seemingly determined a cure of the subphrenic abscess.

CASE 7.—*History.*—A man, aged 53, entered the University Hospital, Oct. 2, 1924, stating that on Sept. 16, twenty minutes after taking a dose of Bromo-Seltzer for headache, he had been seized suddenly with a terrific pain in the upper part of the abdomen. He had lain down on the floor and rolled in agony, and had vomited many times. Large doses of morphine had been given. The abdomen had become rigid and tender and, later, greatly distended. Two days later, he had begun to have diarrhea, with a stool nearly ever hour. After three days of this, he had passed a large quantity of grayish, thin pea-soup-like material by bowel, following which the diarrhea had subsided. He had had slight fever. Tenderness in the upper part of the abdomen had decreased considerably, but distention had persisted. The patient had bilious spells when he ate starchy food, and he belched considerably.

Examination.—The pulse was 104; the temperature, 100, and respiration, 28. There was some limitation of motion of the right side of the chest. There was an area of dulness over the base on the right, where fine crepitant râles were heard. The left side was normal. The abdomen was somewhat distended and was tympanitic throughout. Tenderness was present on deep pressure under the right costal margin and in the epigastrium. Liver dulness was diminished.

An Ewald test meal was given and 60 cc. of fluid removed in forty-five minutes. Free acid was 9; total acid, 40. No blood was noted. The red cells totaled 4,000,000; the hemoglobin content 84 per cent, and leukocytes, 9,600. Urinalysis was negative.

Roentgenographic examination of the chest (fig. 10) disclosed slight cloudiness on the right side and fixation of the diaphragm. On the left there was a zone of gas between the diaphragm and the stomach. The diagnosis was perforated peptic ulcer, with subdiaphragmatic abscess.

Operation and Course.—An operation was performed, Oct. 21, 1924, by Dr. C. J. Rowan under ethylene anesthesia. A segment of the tenth rib was resected in the midaxillary line. Through this an abscess lying between the liver and the diaphragm was opened. About a pint (473 cc.) of thick, odorless pus escaped, but no gas. The cavity seemed to extend well to the left. Tube drainage was instituted.

The patient obtained great relief from the subjective symptoms, but continued to have a low grade febrile reaction. The abscess drained moderately a chocolate colored pus, which on one occasion was distinctly bile stained. Dulness increased over the back and in the axilla of the right side of the chest. A roentgenogram of the chest (fig. 11) on the twenty-fourth day after operation showed a slight mottled shadow above the diaphragm on the right. On the sixty-eighth day, he

coughed up 6 ounces (178 cc.) of pus resembling anchovy sauce, and following this the cough persisted in paroxysms. At this time there was a well marked area of dulness with an abscence of breath sounds over the lower third of the chest posteriorly on the right, and the roentgen-ray examination showed a dense shadow in this area (fig. 12).

A diagnosis of lung abscess was made secondary to infection through the diaphragm. The cough became less, although it persisted and produced a reddish, ropy sputum.

He was discharged, and at home he gained in weight and strength. Because of the persistence of the cough and sputum and the physical signs in the chest, he reentered the hospital in December, 1925, for operation. At this time roentgenographic and fluoroscopic study (fig. 13) showed a well limited, dense shadow, lying against the posterior wall of the chest. A diagnosis of empyema was made rather than lung abscess.

Second Operation and Course.—A second operation was performed, Dec. 29, 1925, under ethylene anesthesia. Resection of a portion of the eighth, ninth and tenth ribs posteriorly opened into a chronic cavity lined by thick pleura and containing several ounces of bloody pus. A small bronchial opening was present at the apex of the cavity.

The patient's condition was satisfactory until the sixth day, when he developed a rapidly spreading erysipelas around the wound. This finally began to subside, but on the fourteenth day the signs of an intracranial infection became manifest, and the patient died from this on the twenty-third day after operation.

An acute perforation of a peptic ulcer was followed by a subphrenic abscess. Partial drainage took place into the bowel. Surgical drainage of the subphrenic abscess seemingly cured this condition. At the time of operation, there was clinical evidence of pleural reaction, but fluid could not be definitely observed. In spite of the satisfactory course of the subphrenic infection following drainage, the pleural involvement progressed to the sudden formation of an empyema which perforated into a bronchus.

CASE 8.—*History.*—A woman, aged 65, was admitted to the University Hospital, May 6, 1926, stating that for two months she had been losing weight and strength, and that her appetite had been poor. Ten days before admission she had suddenly felt weak and had vomited a quart (946 cc.) of thin, black material. The night before she had had a sudden attack of severe abdominal pain, which subsided only after a hypodermic injection of morphine. She had entered the hospital twenty-four hours after the onset of the pain.

The past medical history was negative except for some "gas on the stomach" for several years. She had never had pain prior to the recent attack.

Examination.—The patient was an extremely ill, anemic, poorly nourished elderly woman. There was a normal percussion note over both lungs, but a few crepitant râles were heard over both bases. The heart was normal in size and position. A systolic murmur was heard at the apex. The abdomen showed marked rigidity, and exquisite tenderness over its entire surface with the greatest localization slightly to the left of the epigastrium. A tympanic note was heard over the epigastrium, with a decrease of liver dulness.

The hemoglobin content was 40 per cent. The red cells totaled 2,660,000, and leukocytes, 17,900. The diagnosis was carcinoma of the stomach with perforation.

Because of the patient's poor condition and the length of time that had elapsed since the symptoms of perforation, it was felt that treatment should be expectant. With supportive treatment, improvement took place until the patient was taking liquids readily by mouth. The stools were liquid black. The pain subsided almost completely and the tenderness became less marked. The epigastrium began to show a definite fulness. The temperature reached normal on the fifth day and then began to climb steadily. On the twelfth day, respirations suddenly jumped to 40, and the signs of fluid were found in the left pleural cavity for the first time. This was corroborated by roentgen-ray examination.

Operation and Course.—An operation was performed, May 18, 1926, under nitrous oxide. Aspiration in the eighth interspace posteriorly found a thin serosanguineous fluid with no fibrin flakes in it. The puncture wound was sealed. Incision was made in the seventh interspace anteriorly at the costal margin. At the upper angle, in cutting through the diaphragm a small opening was made in the pleura. This was repaired by suture. The incision was carried forward and the cartilage of the seventh rib removed. Aspiration at this point revealed foul, dirty white, thin pus. An opening was made along the needle into a large cavity containing pus and gas. The borders of it could not be reached by the finger. Shortly after the abscess was opened, it was noted that fluid was escaping from the sutured rent in the pleura, so the latter also was drained.

The patient's condition was unsatisfactory. Pneumothorax developed with respiratory embarrassment, and she died on the fifth day after operation.

Necropsy.—Postmortem examination disclosed a large subphrenic cavity lying between the anterior wall of the stomach, the undersurface of the liver and the diaphragm. This was secondary to a perforation through a benign ulcer situated on the anterior surface of the stomach near the lesser curvature. The left pleural cavity contained considerable thin, cloudy, blood stained fluid and air. The lung was collapsed. There was no communication between the subphrenic abscess and the pleural cavity.

An acute perforation of a gastric ulcer was followed by a subphrenic abscess. During the progress of this, the chest was examined carefully each day, and there was no evidence of fluid in the pleural cavity until the twelfth day, when there was a sudden and marked accumulation. This was not grossly infected at the time of operation, but became so subsequently owing to the opening of the pleura at operation.

CASE 9.—*History.*—A man, aged 67, entered the University Hospital, Jan. 30, 1923, stating that about ten months before he had begun to have pain in the lumbar region on the left and frequency of urination. He had lost 40 pounds (18.1 Kg.) in weight over a period of several weeks and had begun to have a frequent, hard, nonproductive cough. He had been sent to Colorado for tuberculosis but had been refused admission to a sanatorium. The prostate had then been removed. The pain in the left side of the back had persisted, and he had had a febrile course since the onset.

Examination.—The patient was greatly emaciated. There were signs of fluid in the left side of the chest below the angle of the scapula. The heart apparently was not displaced. There was slight tenderness below the twelfth rib on the left. The leukocyte count was 31,200. The urinalysis was: specific gravity, 1.005; albumin +; many pus cells and a few granular casts.

A cystoscopic examination by Dr. N. G. Alcock demonstrated that the left kidney secreted satisfactorily, although dilatation of the pelvis increased the lumbar pain. Roentgen-ray examination showed a dense shadow occupying the lower portion of the left side of the chest. The heart was not displaced. The diaphragm could not be outlined. The diagnosis was chronic empyema.

Operation and Course.—An operation was performed, Jan. 30, 1923, procaine hydrochloride infiltration being used. Subperiosteal resection of the ninth rib on the left posteriorly opened into a large empyema cavity containing thick pus. In the posterior outer quadrant of the diaphragm about one-half inch (1.2 cm.) from the chest wall, was a defect which admitted the index finger. This opened into a cavity lying below the diaphragm in the region of the left kidney. A second incision of large size, was made below the twelfth rib to drain the subphrenic abscess. A pure culture of *Staphylococcus aureus* was grown from the pus.

There was considerable drainage, especially from the lumbar incision. The general improvement was gradual. The patient left the hospital with both cavities considerably smaller but still draining. He died several weeks later from cerebral hemorrhage (?)

The initial infection was probably perinephric, with later perforation of the diaphragm and development of an empyema.

Case 10.—*History.*—A woman, aged 40, entered the University Hospital, Feb. 4, 1919, stating that about two weeks before she had been seized suddenly with a severe chill, which had been followed by pain in the right side of the chest. She had had a continuous high fever, which had reached 103, but had raised no sputum.

Examination.—Results of examination were negative except for the chest. There were signs of fluid in the lower two thirds of the right side of the chest. This was confirmed by the roentgenographic observations. The leukocyte count was 23,000. Aspiration obtained 500 cc. of greenish pus containing a diplococcus. The diagnosis was acute empyema.

Operation and Course.—An operation was performed, Feb. 16, 1919, under nitrous oxide anesthesia. Aspiration at the site of the former puncture obtained no pus. A segment of the rib immediately below was resected. When an opening was made through the rib bed, it was found that the diaphragm had been passed through and the peritoneal cavity opened, exposing the liver. The wound in the diaphragm was sutured with catgut. The rib above was resected and an empyema opened. Drainage by tube was instituted.

The cavity in the pleura drained a moderate amount and became gradually smaller. A high postoperative febrile course was followed by a chill on the eighteenth day. The temperature reached normal, however, on the thirtieth day, and the patient was discharged as cured on the fifty-fifth day.

Shortly after she arrived home, pain developed along the right costal border. This was severe and sharp at times and was aggravated by the taking of food. It also was increased after urination. The side became sore, and she could turn with great difficulty. She had no cough. She reentered the hospital two weeks after discharge.

The empyema incision was healed. There was some dulness over the base of the right lung posteriorly. From the tenth rib down into the flank there was

marked tenderness, and this continued forward along the costal margin to the ensiform. The leukocyte count was 16,200. The diagnosis was subphrenic abscess.

Second Operation and Course.—A second operation was performed, May 18, 1919, under nitrous oxide anesthesia. An incision made in the sixth interspace anteriorly opened into a large subphrenic abscess lying between the diaphragm and the liver. It was well localized. A pure culture of pneumococcus was grown from the pus.

The patient made an uneventful recovery.

Infection from the empyema traveled through the injured diaphragm to produce a subphrenic abscess. This is the only case in this series in which infection extended from above the diaphragm to below the diaphragm.

SUMMARY

The diaphragm is an efficient barrier to the extension of infection from pleura to peritoneum.

Because of the lymphatic drainage, extension of infection from a subphrenic abscess to pleura or lung occurs commonly.

A gross break in the diaphragm takes place in the majority of cases with a direct connection between an infraphrenic and a supraphrenic involvement.

Drainage of either the infraphrenic or the supraphrenic infection will lead to a cure of both in some cases. Drainage of each area of involvement will be necessary in most cases.

ABSTRACT OF DISCUSSION

DR. EDWARD ARCHIBALD, Montreal: I looked into the matter of transphrenic infection from above downward many years ago—it must now be nearly twenty years ago. I reviewed the literature and found that out of some 500 cases of subphrenic abscess only seventeen were reported as extending from above downward; the balance were from below upward. The perforation of the diaphragm from above downward apparently is difficult.

THE MEDIASTINUM

PATHS OF EXTENSION OF INFECTION FROM FOCUS IN MEDIASTINUM*

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The group of cases considered here has some unusual features which aroused our interest and led us to make this study of the mediastinum. Frequently the roentgenograms of patients who enter the clinic present shadows that give rise to various interpretations. In general, these roentgenograms show a widening of the normal central or mediastinal shadow. We realized that mediastinal disease was never diagnosed by roentgen-ray observation until this widening had made its appearance; in other words, until the disease had extended beyond the limits of what is usually understood as the mediastinum. The problem that has interested us most has been to determine whether the spread of mediastinal disease follows definite anatomic paths, and to endeavor to discover these paths.

EMBRYOLOGY

A knowledge of the development of this region is important, and its embryology explains many of its peculiarities and the close relationship in the adult between what at first appear to be widely divergent structures.

In the earliest stages of the embryo, the mesoderm develops as a layer or mass of cells between the ectoderm and the entoderm, and appearing first beneath the primitive streak, spreads out as a thin plate in an ever widening circle. The portion beneath the primitive streak is spoken of as the axial mass of mesenchyme, while the peripheral area is spoken of as the paraxial mass. Soon after its appearance a cleft occurs in the paraxial portion, which separates the mesenchyme into two layers, one attached to the ectoderm, known as the somatopleure, the other associated with the entoderm, and spoken of as the splanchnopleure, while the cleft or cavity contained between these is called the coelom. In the adult, portions of this coelom become the pleural, pericardial and peritoneal cavities. The pleura is developed from the mesoderm which lines this coelom, and this mesoderm is continuous with the axial mass of mesoderm beneath the primitive streak. The axial mass will ultimately become the connective tissue of the posterior portion of the adult mediastinum.

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Within the first week or ten days the head of the embryo grows forward, and the foregut is formed from a portion of the yolk sac, which is drawn up cephalad with this forward growth; a portion of the coelom on each side accompanies this development.

The heart is developed ventrad to this portion of the foregut and becomes surrounded by the adjacent portion of the coelom as the pericardium.

The primitive trachea appears ventrad as a bud on the anterior surface of the foregut posterior or dorsad to the heart and grows downward or caudad into the axial mass of mesenchyme. Its lower end becomes surrounded by the adjacent portion of the coelom as the pericardium to form the primitive lung buds. These buds grow out laterally on both sides toward each coelomic cavity and eventually project into these cavities, pushing ahead of them a portion of the splanchnopleure, which thus covers them and which becomes the adult visceral pleura and subpleural areolar tissue. Thus it is seen that the areolar tissue of the subvisceral space is continuous with that of the primitive axial mass of mesenchyme. The adult parietal pleura is developed from the mesenchyme of the somatopleure as is also the extrapleural connective tissue, and their intimate connection with the axial mass of mesenchyme is obvious.

The well-known continuity of the connective tissue of the various fascial spaces of the neck with that of the mediastinum, as pointed out by Lerche and others, is readily accounted for by the intimate connection between the mesenchymal mass in which the primitive vessels of the neck develop and that situated mesially between the two coelomic cavities on each side.

The connection between the mediastinal and the retroperitoneal areolar tissues would be anticipated because in the embryo the original axial mass of mesenchyme is the forerunner of both the mediastinum and the mesentery.

A direct and intimate communication thus exists between the connective tissue of the mediastinum proper and that between the broad ligaments of the lung, that of the subvisceral pleural space, that about the larger branches of the bronchial tree, that of the extraparietal pleural space, that of the fascial planes of the neck and that in the retroperitoneal space, arising as they all do from the original mesenchymal mass in the embryo.

ANATOMY

In the adult, it is difficult to demonstrate the minutiae of this region, and on this account these relations often are not appreciated. The usual description of the mediastinum found in textbooks of anatomy may be well adapted to the purpose of enumerating the various structures con-

tained within the mediastinum, but it fails to give a good mental picture which can be retained and employed to visualize in any given case the actual pathologic conditions present, while correlating physical signs and roentgen-ray observations. It is with the hope of supplying this deficiency that we have undertaken this study.

The central portion of the thorax, spoken of as the mediastinum, extends from the posterior surface of the sternum anteriorly to the anterior surface of the anterior common spinal ligament posteriorly. It is limited on each side by the reflections of the right and left pleurae; below, by that portion of the diaphragm situated between the lines of reflection of the pleurae, and above by an imaginary plane passing obliquely from behind through the upper border of the neck of the first rib, downward and forward to the upper border of the sternal notch, which roughly corresponds to the inner border of the first rib.

The pericardium, containing the heart, occupies the largest portion of this space, and it will be found convenient to have the description of the entire space focus about the pericardium, for several reasons: the diseases of the heart and pericardium form a group distinct from the surrounding structures and rarely extend beyond their original limits to involve the remainder of the space. On both physical and roentgenologic examination, the heart and pericardium serve as guides by which to judge the situation of lesions of other structures.

The remainder of the space may well be divided into prepericardial, postpericardial, suprapericardial, right pericardial and left pericardial portions.

The prepericardial portion varies considerably in extent because of the pronounced variations in the lines of reflection of the anterior edge of the right and the left pleural cavities, as pointed out by Tanja.[1] This space is limited in front by the muscles lining the posterior surface of the sternum and by the periosteum covering that bone. The communication on each side with the space external to the parietal pleura is particularly free, as the parietal pleura has no firm connection but is rather widely separated from the sternum by loose areolar tissue. In fact, the pleura does not become adherent until it is in contact with the costal cartilages. The pathologic process most frequently encountered in this region is disease, usually tuberculous, of the chondrosternal or chondrocostal junctions. This does not involve the mediastinum but is situated in the extrapleural connective tissue, external to the parietal pleura. Rarely, as in case 3, a mediastinal abscess may extend forward and point beneath the sternum near the origin of the diaphragm.

The right and left pericardial portions have slight clinical significance as they are represented by a meager amount of areolar tissue between

1. Tanja, T.: Ueber die Grenzen der Pleura—Hohlen bei den Primaten und einigen Säugetieren, M. J. **17,** 1891.

the pericardium and the pleurae on each side. This areolar tissue, also, is firm and unites the serous membranes firmly with each other, except along the line of reflection on the diaphragm. It is here that infection extends either forward or backward from the postpericardial portion, to the prepericardial portion, or vice versa. No lymphatic vessels appear to pass between the prepericardial and postpericardial portions which might determine the course that a given focus of infection would travel.

The postpericardial and suprapericardial portions are best considered together and constitute, in most persons' minds, the mediastinum. They have important connections and extensions not usually recognized, and contain most of the important structures within the thorax except the heart and lungs. They are continuous with one another and are separable only by a most artificial and arbitrary line of division which has neither a clinical nor an anatomic basis, except that of tradition introduced for the sake of facilitating description. They are bounded on each side by the reflections of pleurae extending from the pericardium in front to the side of the bodies of the vertebrae behind. Posteriorly, they are limited by the anterior common ligament of the spine and the periosteum of the bodies of the vertebrae. Below, the space is limited by that portion of the upper surface of the diaphragm which extends from the attachment of the pericardium on the central tendon to its points of origin on the body and transverse processes of the twelfth dorsal vertebra. It should be noted that this portion of the inferior wall of the space is placed almost perpendicularly, and that it extends well down below the dome of the diaphragm and the pericardium. The openings for the passage of the esophagus, aorta, thoracic duct, azygos veins and splanchnic nerves are situated in this portion of the postpericardial space.

Above, the suprapericardial space becomes continuous with the fascial planes of the neck without any anatomic guides to distinguish the point of transition, which has been arbitrarily designated by a plane passing through the upper or inner border of the first rib and the notch of the manubrium of the sternum.

These two spaces, the suprapericardial and postpericardial, however, are roughly divided into a right and left portion by the arch of the aorta and descending aorta, the great vessels, the trachea and the esophagus.

The arch of the aorta arises from the left ventricle anteriorly behind the sternum and to the right of the median line and passes backward and to the left to become the descending thoracic aorta lying on the left side of the bodies of the vertebrae. The three large vessels, innominate, left common carotid and left subclavian arteries, arise from its upper border from before backward and from right to left; the

esophagus passes behind the trachea and comes to lie to the right and anterior to the descending aorta but slightly to the left of the median saggital plane. These structures thus divide the suprapericardial and postpericardial portions of the mediastinum into a right and left compartment, and because of their more or less firm and fixed connections influence markedly the direction of extension of neoplasms or inflammatory exudates arising in this region.

The superior vena cava, with the right azygos vein entering it from behind as it comes forward above the right main bronchus, is contained in the right compartment; many more lymphatic glands are found on the right side than on the left, which would account for the increased frequency of the occurrence of neoplastic and inflammatory processes on the right side. The mediastinal pleura, supported only by readily compressible lung, forms the right wall of this compartment and offers only slight resistance to the extension of inflammatory or neoplastic processes arising in the lymphatic glands or areolar connective tissue in this region.

The paths of extension from these two portions of the mediastinum are important; about opposite the posterior wall of the pericardial sac on either side the mediastinal pleura is reflected toward the lung to form the two leaves of the broad ligament which, as they pass upward from the diaphragm, separate and then surround the hilum or root of the lung with the structures which enter and leave here.

Between the leaves of these ligaments is a collection of areolar connective tissue which is continuous with that of the postpericardial portion of the mediastinum. This areolar tissue extends beneath the visceral pleura to form a distinct layer and at the root of the lungs reaches into the pulmonary substance along the course of the bronchial tree as far as the tertiary bronchi. We believe that it is the involvement of this areolar tissue which gives rise to many of the so-called root shadows seen by roentgen ray.

In addition to these paths of extension through the hilum and the broad ligaments, these two portions of the mediastinum, both postpericardial and suprapericardial, communicate on each side with the layer of areolar connective tissue which is situated outside of the parietal pleurae and which is known as the endothoracic fascia, or subserous layer. This communication is not uniform, as the pleura is more adherent in some parts than in others, as has been shown by Bérard and Mallet-Guy.[2] These authors demonstrated that the line of greatest adherence was an irregularly toothed one along the line of articulation of the ribs with

2. Bérard, L., and Mallet-Guy, P.: Voies d'acces de l'oesophage thoracique: Le decollement de la pleure costo-vertebrale, Lyon chir. **22**:457-476 (July-Aug.) 1925.

the vertebrae; this extends outward along the course of the ribs, the adherence being much less along the intercostal muscles. The extension of the inflammatory exudates along this path results in a massive collection of fluid which strips off the pleura and accumulates outside of it; this will give rise to characteristic shadows with sharp, well defined borders, which materially widen the normal mediastinal shadow.

The postpericardial portion of the mediastinum communicates with the retroperitoneal tissues through the several openings noted above; namely, the esophageal, most anteriorly placed immediately behind the pericardium; the aortic between the two crura and in front of the body of the twelfth dorsal vertebra, and the openings for the two splanchnic nerves represented by slits in the crus on each side where the fibers are separated to allow their passage. It should be noted that all these openings form communicating paths between the postpericardial portion of the mediastinum and the retroperitoneal tissue. We wish to emphasize the fact that this retroperitoneal space is distinct and independent of the space contained within the sheath of the psoas muscle. This sheath, it is true, extends above the diaphragm and passes through an independent opening in it on each side, but there is no pathway of communication between the postpericardial portion of the mediastinum and the areolar tissue within the psoas sheath.

EXPERIMENTS

We have made a number of injections into cadavers in order to demonstrate the embryologic relationships, and have employed Gerota's fluid[3] for this purpose. Gerota's fluid consists of a mixture of turpentine 3 parts, ether 15 parts, Prussian blue 2 parts. It has been employed extensively to demonstrate the lymphatic vessels, and has several advantages: (1) It does not stain the tissues; (2) it offers an excellent and striking contrast readily distinguished, and (3) it flows most readily. Our procedure was as follows.

The spinous processes and the laminae of the first, second and third dorsal vertebrae were removed, together with that portion of the spinal cord exposed by this procedure. We passed an 18 gage needle from behind forward through the second intervertebral disk until its tip had entered the suprapericardial portion of the mediastinum, that is, the superior mediastinum, and then injected from a syringe or allowed to flow by gravity Gerota's fluid, the amount of fluid being regulated somewhat by the size of the cadaver. As we employed only infants ranging in age from birth to 2 years, we used from 10 to 40 cc. of fluid.

The results may be summarized as follows: The fluid injected entered the mediastinum and completely filled its suprapericardial and postpericardial portions. From here it passed laterally between the layers of the broad ligaments and spread out to a variable extent in an irregular manner beneath the visceral pleura, especially over those portions of the lower lobe which lie in the vertebral gutter; it did not penetrate deeply into the pulmonary tissue except as it passed along the course of the lower bronchi. A small amount

3. Gerota: Anat. Anz. **61,** 1926.

followed the course of the larger bronchi into the pulmonary structure. None of the fluid injected passed between the pleura and the diaphragm or between the pleura and the pericardium.

Another extensive area that was invaded by the fluid injected was the areolar tissue situated between the parietal pleura and the bodies of the dorsal vertebrae and the inner surface of the ribs and intercostal muscles.

The distribution here was uniform and distinctive and corresponded in many particulars with the irregularities obtained by Berard and Mallet-Guy. These

Fig. 1.—Lateral view of cadaver after the injection of an opaque mixture into the mediastinum: The injection mass in the retropharyngeal region above is widened in the suprapericardial portion of the mediastinum and narrowed in the posterior portion as it descends to the diaphragm.

authors demonstrated that the parietal pleura was more adherent over the ribs from the neck outward than over the intercostal muscles, and in addition showed a vertical line of increased attachment along the bodies of the vertebrae. The fluid injected in our experiments also spread more widely along the intercostal spaces than over the ribs, but we did not note any indication of a barrier to its free passage which might correspond to the adherent

line on the bodies of the vertebrae, except that if the injection was made too rapidly or the amount of fluid was unduly large the pleura ruptured along this line. This might be interpreted as an indication that the infiltration by the fluid was slower at this point owing to greater adherence.

The fluid appeared beneath the skin of the back, with an invasion of the areolar tissue, having emerged through the openings for the passage of the posterior branches of the intercostal nerves. Below, it invaded the retroperitoneal areolar tissue through the esophageal opening and through the slits in each crus of the diaphragm for the passage of the great splanchnic nerve.

Fig. 2.—Cadaver after the injection of an opaque mixture into the mediastinum: There is a diffuse shadow from the base of the skull to the diaphragm with bilateral widening of the normal mediastinal shadow, especially above. On the right side the root shadow is due to the infiltration of the subvisceral pleural space through the broad ligament.

The extent of invasion of this retroperitoneal space varied considerably and appeared to be most pronounced when the cadaver was suspended vertically during the injection and was maintained in that position for some time afterward. The fluid injected did not pass through the aortic opening in the diaphragm. Above, the fluid invaded the neck to a wide extent. Its distribution was so general that it was impossible to distinguish whether one fascial compartment was more extensively involved than another. The fluid surrounded the vessels, both jugular veins and carotids well up toward the base of the skull; as it also appeared behind the esophagus and pharynx, it must also

have entered the retrovisceral space. This intimate relation has been emphasized by Lerche [4] and others.

When either the pressure or amount of fluid injected was unduly increased, the pleura was ruptured and the pleural cavity was flooded; otherwise it remained free. This rupture occurred either along the line of reflection, along the bodies of the vertebrae as noted above, or along the posterior leaf of the broad ligament near the root of the lung.

Another series of injections, following the same technic was made, employing in place of Gerota's fluid a mixture of equal parts of fresh defibrinated human blood and a 50 per cent solution of sodium iodide. This solution is opaque to the roentgen ray. It forms an injection medium which presents a pronounced contrast at the time of injection, but the color does not last and slowly diffuses into the surrounding tissues.

A series of roentgenograms was taken before and after the injection; the latter showed the shadow in the neck, extending down the mediastinum to the diaphragm. In addition, root shadows appeared which suggest those seen in the cases of mediastinitis. The distribution of the fluid injected was identical with that obtained when Gerota's fluid was employed (figs. 1 and 2).

CONCLUSIONS

There are definite paths by which infections may spread from a focus in the mediastinum: (1) through the broad ligaments of the lungs beneath the visceral pleura and into the substance of the lung down the larger branches of the bronchial tree; (2) posteriorly along the bodies of the vertebrae to the endothoracic fascia outside of the parietal pleura; (3) upward into the fascial planes of the neck; (4) downward into the retroperitoneal connective tissue; (5) anteriorly beneath the sternum outside of the anterior pleural reflections; (6) exudates in zone 1 will give rise to roentgen-ray shadows often spoken of as root shadows, and (7) exudates in zone 2 show large fluid collections which widen the normal mediastinal shadow.

REPORT OF CASES

Case 1.—A. P., a man, aged 18, an Italian, was admitted to Bellevue Hospital, service of Dr. J. A. Miller, Oct. 5, 1922, and was discharged, November 14. The diagnosis was mediastinitis, with extension into the broad ligaments beneath the visceral pleura (figs. 3 and 4).

The family history was negative. The patient had had short attacks of bronchitis one and three years before, each lasting about three weeks. Five weeks before admission, he began to have fever and cough, raising a few ounces of mucopurulent sputum each day. This condition continued until the time of admission.

There was an area of dulness in the right side of the lower part of the chest posteriorly. There was bronchial breathing in the center of this area with subcrepitant râles. Friction rubs were heard over the lower half of both

4. Lerche, William: Suppuration in Posterior Mediastinum, Arch. Surg. 8:247 (Jan.) 1924.

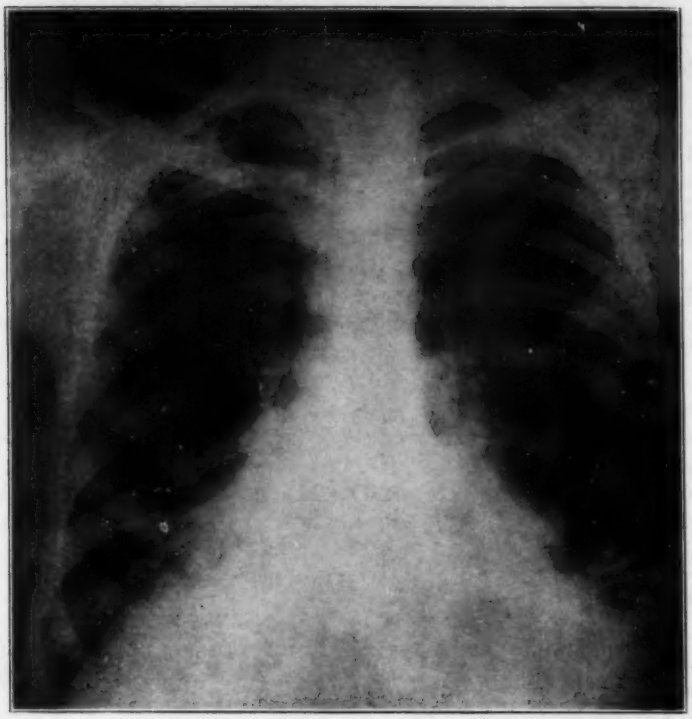

Fig. 3 (case 1).—Bilateral widening of the mediastinal shadow from the hilum to the diaphragm, with irregular outline and extension outward.

Fig. 4 (case 1).—Marked changing of shadow coincident with recovery of patient.

sides of the chest, more pronounced on the right. The white blood cells totaled 49,000; polymorphonuclears, 93 per cent and lymphocytes, 7 per cent.

A tentative diagnosis of either a double pneumonia centrally located or a mediastinal abscess was made.

Roentgen-ray examination showed a bilateral triangular shadow in the lower portion of the chest centrally located. The apex was at the hilum, and as it descended it spread out onto the diaphragm. Its borders were not sharp and clear-cut but had an irregular, feathery outline.

The patient recovered after a few weeks in bed, and was sent to a home for convalescents five weeks later. The general condition improved. There was harsh bronchovesicular breathing in the fourth right interspace, and scattered crepitant râles were heard outside the midclavicular line on the left. On discharge, the white blood cells totaled 15,600; polymorphonuclears, 78 per cent, and lymphocytes, 22 per cent. Roentgen-ray examination showed good clearing of conditions and seemed to indicate that the disease had been largely if not wholly mediastinal.

CASE 2.—W. K., an American negro, aged 23, an elevator operator, was admitted to Bellevue Hospital, service of Dr. J. A. Miller, May 1, 1925, and was discharged, September 26. He was readmitted, Feb. 5, 1926, and died February 20. The diagnosis was tuberculosis of the mediastinal glands and superior mediastinal abscess, with fluid.

The family history was negative. The patient had had influenza in 1918 and gonorrhea in 1921. Eight months before admission he had begun to lose strength and weight. The loss of weight was about 20 pounds (9 Kg.) to the date of admission. Two months prior to admission, he had commenced to cough and had noticed that the sputum was blood streaked; this had continued until the time of admission.

The patient was an emaciated negro with pale mucous membranes. The pulse was rapid; there was a systolic murmur at the apex of the heart; P_2 was accentuated and the first sound at the apex was reduplicated. Breathing was weak and expiration prolonged. There was dulness at the right apex of the lungs and in the midline posteriorly from the second to the fourth thoracic vertebrae. Breath sounds were diminished at the left apex posteriorly. Occasional medium moist râles were heard over both sides of the lower part of the chest. The results of the remainder of the physical examination were negative. The temperature ranged from 98 to 101; the pulse rate, from 80 to 120, and respiration, from 20 to 24. The sputum was negative for tubercle bacilli. The urine was normal. The white blood cells totaled 16,000; polymorphonuclears, 80 per cent; lymphocytes, 16 per cent and transitionals, 4 per cent. The blood Wassermann reaction was negative. Roentgen-ray examination, May 5, showed a large mediastinal tumor.

On May 11, dulness was noted on the right posteriorly from the third to the sixth thoracic vertebrae. Over this area the breath signs were much exaggerated, with an almost amphoric quality, probably due to the transmission of sounds from the main bronchus. Anteriorly, the right side of the chest was somewhat retracted, with marked limitation of motions of the second, third and fourth ribs. There was some tenderness over the seventh rib near its junction with its cartilage.

Roentgen-ray examination, June 1, showed a mediastinal mass on the right side which was irregular in contour, and which extended 2.5 inches (6.2 cm.) at its widest point at the level of the fifth interspace posteriorly. At this time a tentative diagnosis of lymphosarcoma was made, and the patient was referred

for roentgen-ray therapy. This continued until September 9. Physical signs and roentgen-ray reports remained unchanged. The patient became symptom-free, however, and gained 19 pounds (8.6 Kg.). In view of his improvement without any apparent change in the mass, the diagnosis was changed to probable tuberculous lymphadenitis.

Feb. 5, 1926, four and a half months later, the patient was readmitted with the complaint that during the week previous he had become increasingly dyspneic. On examination, bronchial breathing, bronchophony, dulness and many medium moist râles were noted over the right lower lobe. A succussion splash could be heard in the interscapular region. On fluoroscopic examination, a collection of fluid with air above it was seen in the upper part of mediastinum posteriorly. The impression was that of a tuberculous abscess. On February 10, the dulness and bronchial breathing were more marked over the right lower lobe and roentgen-ray examination showed extension with apparently bronchopneumonic densities in the left lower lobe. The temperature ran about 100 and the pulse was thready and weak.

On February 16, the patient coughed up about 6 ounces (178 cc.) of frothy, yellow, purulent, turbid, nonodorous fluid, and fluoroscopic examination showed that the mediastinal fluid level had descended. The cough continued, and the fluid level continued to decrease. February 20, the patient died suddenly.

The final diagnosis was tuberculous lymphadenitis of the mediastinal glands with softening and eventual rupture into a bronchus. Autopsy was not performed.

Case 3.—M. W., a woman, aged 23, a pupil nurse, was admitted to the Presbyterian Hospital, Jan. 28, 1920, stating that she had had influenza eight days before accompanied by a pronounced coryza, but without signs of disease in the lungs. The accessory sinuses of the nose were clear.

On the tenth day of the illness, she had an attack of acute pain in the right upper quadrant of the abdomen, which was made worse on deep inspiration and which radiated into the region of the right scapula. This lasted for three days. On the twelfth day, definite signs of consolidation appeared in the right interscapular region, and the patient developed slight jaundice. The white blood cells totaled 23,600, and the polymorphonuclears, 86 per cent. A blood culture was sterile. The temperature was 104 F., the pulse rate, 112 and respiration, 34. The sputum showed a growth of *Streptococcus mucosus*. Roentgen-ray examination showed pneumonia of the right middle lobe. On the seventeenth day, the roentgen-ray report was that a hydropericardium was shown, but clinical evidence of pericarditis was not present at any time. On the fortieth day, there was an increase in precordial dulness, and the roentgenogram showed a shadow with the left border clear and the right border fuzzy. On the forty-fifth day, fluoroscopic examination showed pulsation in the left border of the heart shadow and an absence of pulsation on the right side, while the diaphragm was fixed on the right side but movable on the left. The right side of the diaphragm was high. There was a musical systolic blow over the lower end of the sternum. The sounds were always indistinct at the apex, and there was a systolic murmur over the aortic and pulmonic areas. On the fifty-second day, roentgen-ray examination showed the heart shadow of normal size with a 6 foot tube, while the diaphragm was high and firmly fixed.

The patient continued to run a febrile course of an irregular type, while the signs in the chest slowly changed. On the one hundred and thirtieth day of the illness, there was dulness over the right side of the chest posteriorly from the eighth space downward, with feeble breathing and a few fine râles.

These signs extended into the axilla, where they merged into an area of absolute flatness, which was triangular with its base on the right border of the sternum extending from the third rib downward. Over this area there was absence of tactile fremitus, voice and whisper. There was a distinct point of tenderness in the fourth intercostal space just outside the right border of the sternum. Roentgen-ray examination at this time showed the right side of the diaphragm high, with a widened cardiac shadow and an obliteration of the angle between the heart and the diaphragm on the right. A week later, the physical signs had not meterially changed, but a roentgenogram taken at this time presented notable changes. The diaphragm on the right side was still markedly elevated, and the shadow of the right side had greatly increased both outward and above. A diagnosis of mediastinal or subphrenic abscess was made and the anterior approach was chosen, based on the pronounced physical signs anteriorly and the presence of an extremely tender spot in the fourth interspace.

On the one hundred and thirty-fifth day of the illness, the patient was operated on and an abscess, situated above the diaphragm between the pericardium and the right pleura and extending upward to the region of the right bronchus, was drained. Because some of those in attendance were of the opinion that the trouble was below the diaphragm, an exploratory celiotomy was first performed. The liver was normal and the diaphragm much elevated. The wound was immediately closed; a portion of the fifth and sixth costal cartilages and the adjacent ribs were then resected and the abscess drained, as noted above. The patient made a complete recovery after five weeks.

CASE 4.—J. O., a man, aged 28, a laborer, entered Bellevue Hospital, Oct. 27, 1924, complaining that he had had pain in the right side of the chest for the preceding two weeks. He had had a cough for years and had noticed foul sputum for the last seven months, but prior to three weeks before admission there had been no other symptoms. At that time he had had a cold with sneezing and coughing, sweating on exertion, and had noticed yellow, foul sputum. One week later, he had had a sudden attack of dizziness and severe pain between the last two ribs on the right. This pain had remained for four days and had then shifted to the other side of the chest in the scapular region. The cough and sputum were now less frequent, and he felt generally ill.

The patient had had pleurisy on the right seven years before, and had been sick for two weeks.

He was poorly developed and nourished. He breathed easily, but appeared chronically ill. The head, neck, heart, abdomen, reflexes, skin and genitals were normal. There was marked clubbing of the fingers.

The chest was rounded and emphysematous, with the supraclavicular fossae deepened. On the right anteriorly from the apex to the third space, sounds were faint, with increased fremitus and voice, bronchovesicular breathing and a few moist râles. Posteriorly, there was dulness from the apex to the spine of the scapula, with signs similar to those in the anterior part of the chest. From the spine of the scapula to the base there were flatness, diminished breath sounds and bronchial voice; no râles were heard. In the right axillary region, the chest was resonant, the breath sounds emphysematous, and a few moist râles were heard. On the left, from the apex to the angle of the scapula, there were dulness, bronchovesicular breathing, increased voice and fremitus and numerous moist râles.

On admission the temperature was 101.4 F., the pulse, 112, and respiration, 24. The systolic blood pressure was 125; diastolic, 60. The white blood cells

totaled 16,800; polymorphonuclears, 90 per cent. The urine was normal except for a very faint trace of albumin.

A tentative diagnosis of chronic pulmonary tuberculosis, with possibly encysted fluid, was made. The sputum was negative for tubercle bacilli on repeated examinations. The roentgen-ray report, Oct. 31, 1924, was, "There is an encysted effusion arising from the posterior, costophrenic portion of the right pleural cavity extending upward along the spine. There are productive changes in the bronchial walls of the left lower lobe."

The temperature ranged from 98 to 101, the pulse from 88 to 120. The signs remained essentially the same. Both by fluoroscopic examination and in

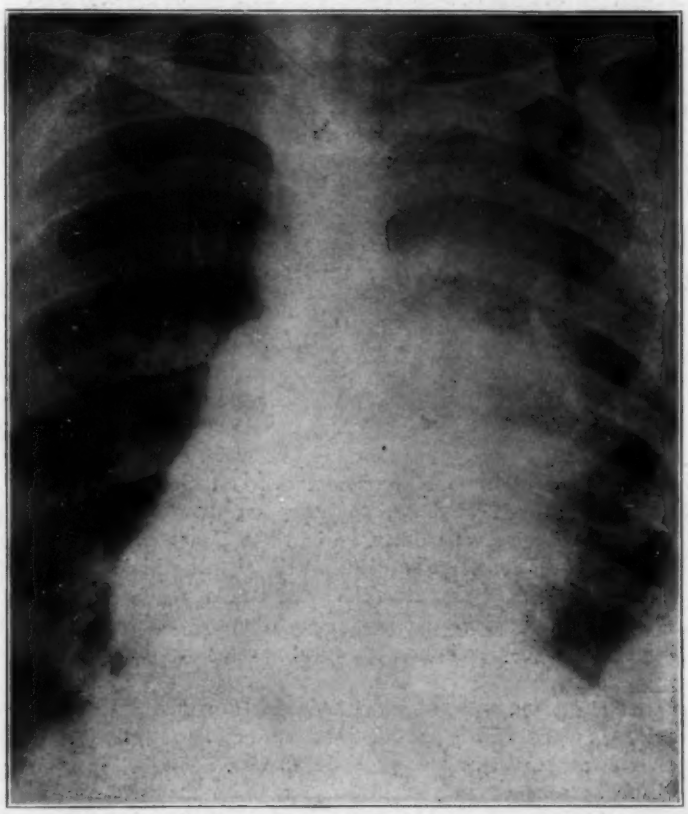

Fig. 5 (case 4).—Mediastinal abscess with enlargement of the mediastinal shadow to the right; the contour of the shadow of the arch of the aorta on the left is normal.

the roentgenograms, an encysted collection of fluid was noted to the right of the spine, but this could not be aspirated successfully. On November 6, a fluid level was first noted, and diagnoses of a mediastinal empyema which had ruptured into a bronchus and lung abscess were both considered. On November 14, postural drainage was instituted, and the temperature promptly came to normal. The sputum, which had been from 8 to 10 ounces (236 to 295 cc.) daily, gradually diminished to 2 or 3 ounces (59 or 89 cc.). Both roentgen-ray examination and physical signs showed progressive disappearance of the

Fig. 6 (case 4).—Mediastinal abscess following rupture, emptying through bronchus. The fluid level and partial clearing of the shadow above should be noted, especially the vertical shadow of the old abscess wall, representing the thickened extrapleural tissue.

Fig. 7 (case 4).—Mediastinal abscess completely emptied, showing persistence of vertical shadow.

fluid collection. The bronchial changes and bronchiectasis in the left lower lobe persisted.

Jan. 20, 1925, a bronchoscopic examination was made. There was a large amount of foul sputum in the larynx and trachea. This was traced to the left bronchus. No pus was found in the right bronchus. The pus from the left bronchus appeared to come from the lower lobe. The lumen of this bronchus was strictured, and the walls had undergone extensive ulceration, so that beyond the mouth of the bronchus of the upper lobe no normal mucous membrane could be seen. The narrowed ulcerated bronchus was like the mouth of a fistulous tract, from which foul pus was seen welling up. The appearance suggested an extensive bronchiectasis of the lower lobe.

During January and February, the temperature remained normal, but the sputum increased again to from 7 to 10 ounces daily (207 to 295 cc.). This was prior to the time when iodized oil 40 per cent was used for injection of the lungs. It was thought that the patient had a mediastinal abscess com-

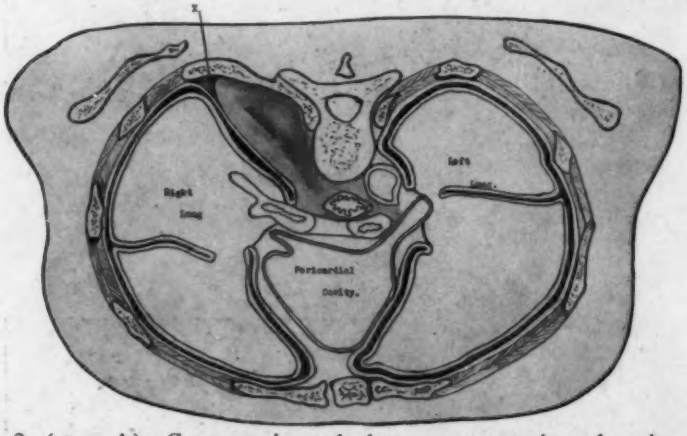

Fig. 8 (case 4.)—Cross-section of thorax representing the site of the abscess outside of the parietal pleura and communicating with the mediastinum. The thickening at the lateral border, X, causes the vertical shadow.

municating with the left bronchus; therefore, in March, a left posterior mediastinotomy was performed. No collection of pus was found in the mediastinum. The pleura was free over the left lung, but a bronchiectatic condition of the lower lobe was noted. The wound was packed until adhesions had formed, and then a cautery partial pneumonectomy was performed. Following this there was considerable improvement for about eight months but not complete alleviation of symptoms.

On account of the recurrence of fever and increase in sputum, seven months later he again came for treatment. Following an operation for further destruction of the lower lobe, he developed a pyopneumothorax and died, about one year after the acute onset of the present illness.

CASE 5.—J. C., a man, aged 27, a laborer, was admitted to the First Surgical Division, Bellevue Hospital, July 20, 1926, with a stab wound in the right side of the back. No other details were given.

Below the twelfth rib on the right was a wound 1 inch (2.5 cm.) long, bleeding profusely. The abdomen was soft but not tender. The chest was

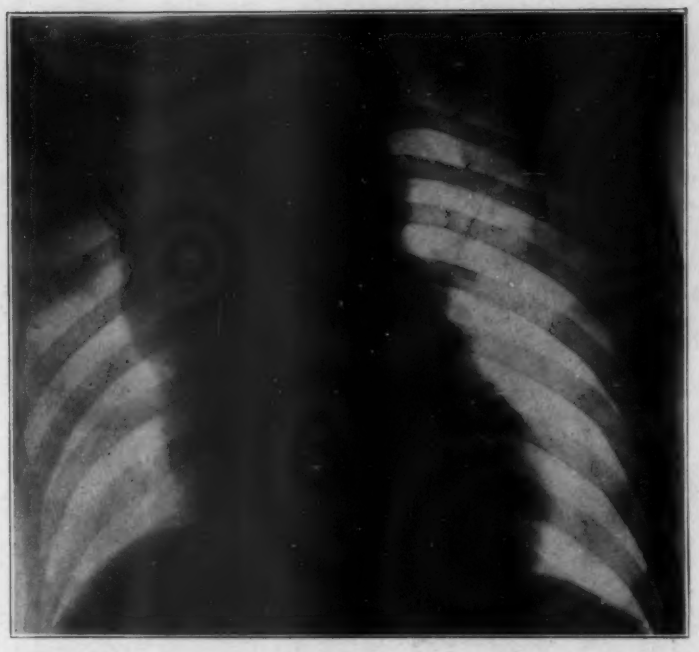

Fig. 9 (case 5).—Appearance before operation: There is definite widening of the upper mediastinal shadow toward the right, a normal shadow of the arch of the aorta on the left, and an enlarged heart shadow.

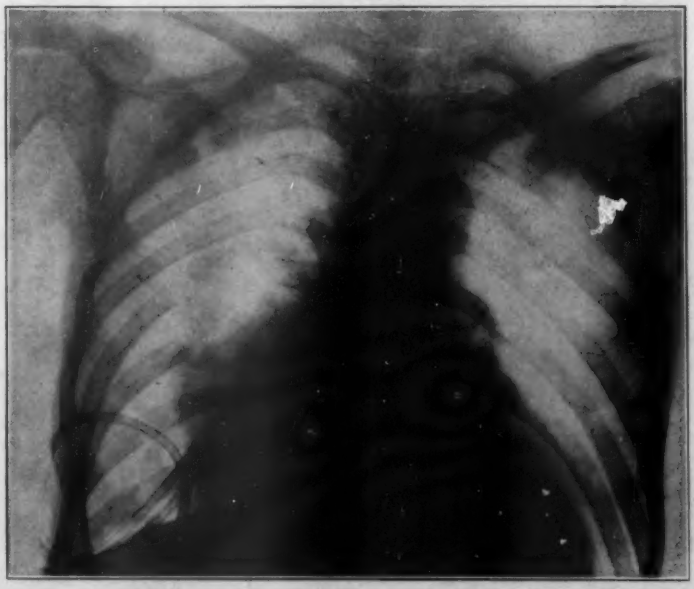

Fig. 10 (case 5).—Appearance after operation: The abscess has been drained by the posterior resection of the sixth and seventh ribs. The shadow of the mediastinitis may be seen extending to the diaphragm behind the heart shadow.

clear. The pulse rate was 100; temperature, 100, and respiration, 24. The urine was red and cloudy and showed a trace of albumin and many red blood corpuscles. The systolic blood pressure was 104, diastolic, 75; three hours later, the systolic was 140, the diastolic, 80. In view of the injury to the kidney, the wound was explored extraperitoneally. The tissues were filled with blood clot, but only a small laceration of the kidney was found. The peritoneum appeared uninjured. The wound was drained and the kidney was not disturbed.

The patient's condition was good for seven days; then the temperature ranged from 101 to 104 F., and the pulse rate from 100 to 110. A diagnosis of subphrenic abscess was considered, but a roentgen-ray examination, August 3, showed no pathologic condition in the lungs nor any elevation of the diaphragm.

Fig. 11 (case 5).—Appearance after operation: The abscess and mediastinitis shadows have disappeared, and there are bilateral root shadows that were not present before the attack, as shown by roentgen-ray examination. The heart shadow is normal.

Cystoscopic examination, August 6, gave normal results for both kidneys.

Because of the persisting sepsis, however, the wound was reopened and a large collection of pus was found in the perinephric tissues. This wound was left wide open with the kidney lying in it superficially, and was treated with surgical solution of chlorinated soda (Dakin's solution). There was temporary improvement, but the temperature soon resumed its septic character, with wide daily swings.

August 14, dulness was noted at the base of the right side of the chest, and a friction rub was heard well posteriorly. The pulse was rapid and there was marked anemia.

August 17, roentgen-ray examination showed a vertical collection of fluid to the right of the spine from the eighth to the third rib. The heart shadow was enlarged and apparently rotated. A diagnosis of mediastinal abscess was made, and the abscess drained by a right posterior mediastinotomy, with resection of the heads of the sixth and seventh ribs. Following this the patient gradually improved. Roentgen-ray examination showed progressive clearing of the mediastinum. Small root shadows persisted. The patient seemed better and the wounds appeared healthier; after fifteen days, the temperature ranged from normal to 100, with occasional flares. On the twenty-sixth day postoperative his temperature suddenly rose to 104 F. and his pulse

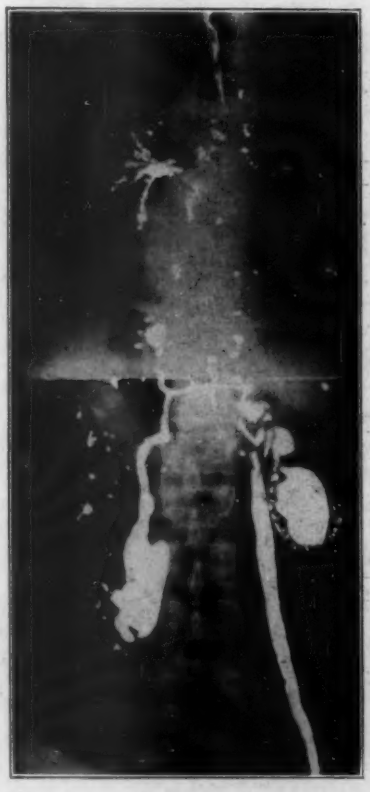

Fig. 12 (case 6).—Mass of iodized oil, 40 per cent, injected into sinus of the thigh, crossing the median line on the body of the twelfth thoracic vertebra; i. e., within the mediastinum.

rate to 140. The abdomen was rigid and distended, and a diagnosis of diffuse peritonitis was made. He died seven days later, thirty-four days after the mediastinotomy, or on the seventy-first day of the illness.

Autopsy showed a suppurative nephritis of the right kidney, an acute diffuse suppurative peritonitis, a drained suppurative mediastinitis and an edema of the right lower lobe about the hilum, but no pneumonia.

Case 6.—P. G., a man, aged 47, an Italian tailor, did not recall having received any severe injury. The present illness had begun about five years

before, with pains in the lumbar region. An abscess in the back had been drained, and had healed after several months. The patient had resumed work and had remained well for four years, when he developed a slight, productive cough, with mucopurulent sputum. Shortly after this he had developed pain and swelling in the right hip. This had been incised and a large quantity of pus had been evacuated. The tissue obtained at the time of operation showed tuberculosis. This sinus had never healed, but the patient was positive that the cough had improved since the operation on the hip.

The right lung apparently was clear. There was impaired resonance in the left lung from the apex down to the seventh vertebral vertebra. Breathing was

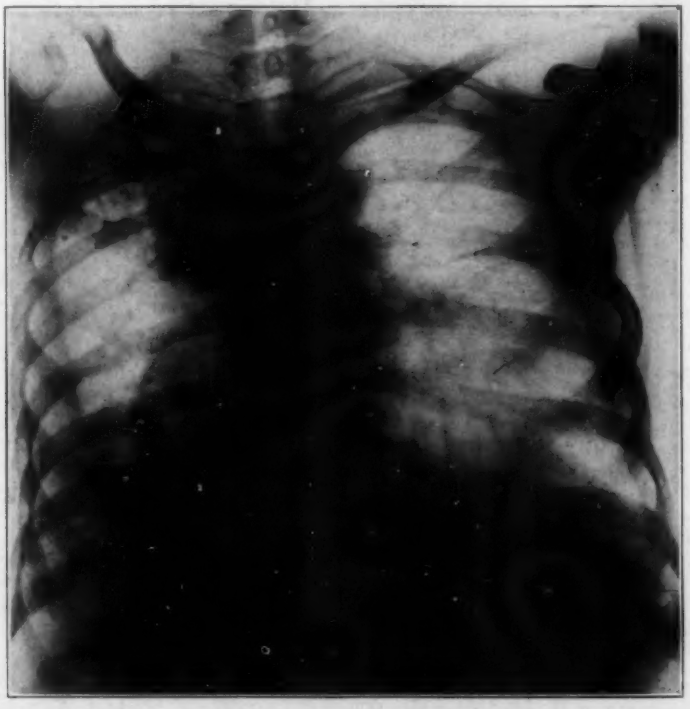

Fig. 13 (case 7).—Appearance before operation. There is a definite widening of the upper mediastinal shadow toward the left ducto enlarged tuberculous lymph nodes.

harsh, especially on expiration, which was prolonged and bronchial in character. A few crepitant râles were heard over the left base posteriorly. In the right thigh, about 10 cm. below the crest of the ileum there was a sinus discharging a large amount of pus. This sinus appeared to run upward anterior to the neck of the femur and beneath Poupart's ligament.

The temperature was 100 F.; the pulse rate, 104, and respiration, 24. The Wassermann reaction was negative. Repeated sputum examinations were negative for tubercle bacilli.

Iodized oil 40 per cent was injected in the sinus in the thigh, and shortly afterward he coughed up the oil. Roentgen-ray examination showed a shadow

in the retroperitoneal tissue about both kidneys and a shadow in the left bronchial tree. The connection between these two was not demonstrated until the injection was carried out with the patient lying on his ventral surface. The figure shows the result of the roentgenographic series.

The patient refused operation and subsequently died of amyloid degeneration of the liver and kidneys, with ascites.

CASE 7.—Q. W., a Chinaman, aged 18, was admitted to Bellevue Hospital, service of Dr. J. A. Miller, Aug. 30, 1926, and died, September 29. The diag-

Fig. 14 (case 7).—Appearance after operation: The abscess was drained through a left posterior mediastinotomy, with resection of the fifth and sixth ribs; the shadow has disappeared.

nosis was tuberculosis and abscess of the mediastinum. He had been transferred from the Presbyterian Hospital, where the diagnosis had been serofibrinous pleurisy. He had complained of pain in the right side of the lower part of the chest of from three to four weeks' duration. The past history had been essentially negative. The patient had had no other respiratory symptoms, and no cardiac or gastro-intestinal complaints. Six months before admission, he had had a cold, and although the pain in the chest had begun only three or four

weeks before admission, the patient really dated the onset as six months back.

The patient was poorly nourished. The pupils reacted to light and accommodation. The throat was clear. Respiratory motion was limited on the left. There was dulness approaching flatness at the base below the second rib on the left, with absent fremitus and breath sounds. The right lung was clear. The heart was slightly displaced on the right. Sounds were regular; there was a blowing systolic murmur, and P_2 was accentuated. The extremities were normal. The biceps and knee jerks were sluggish.

The red blood cells totaled 3,600,000; the hemoglobin content was 75 per cent; the white blood cells totaled 9,000, and the polymorphonuclears, 44 per cent. The Wassermann reaction was negative. Urinalysis showed a faint trace of albumin and a few casts. No tubercle bacilli were found in the sputum on three examinations. Ova of *Trichiuris trichiura* and *uncinaria* were found in the stools. Thoracentesis performed twice yielded no fluid. Three hookworms were found in the stools after a vermifuge. June 28, the red blood cells totaled 4,200,000; the hemoglobin content was 75 per cent; the white blood cells totaled 5,800, the polymorphonuclears, 52 per cent and the eosinophils, 24 per cent. Repeated roentgen-ray examinations of the chest showed a dense homogeneous shadow at the left base, extending up the left lateral chest wall, and peribronchial infiltration in the left apex.

For the first four or five weeks the patient ran a low, intermittent rise in temperature. The signs in the lungs did not change. Carbon tetrachloride and, later, oil of chenopodium were given as a vermifuge and three hookworms were recovered; after this one expulsion no hookworm ova were found. *Trichiuris trichiura* ova continued to be present. About a week after this, the patient began to have fairly constant pain in the upper part of the abdomen. The abdomen became distended, signs of fluid were present and it had a doughy feel. The pain became worse and more constant, and the temperature began to rise to 103 or 104 F. almost daily. Two or three enlarged glands appeared in the neck. The patient lost weight steadily. The signs in the lungs did not change. Three attempts at aspiration of the chest were unsuccessful. There were no meningeal symptoms or signs. The patient was transferred to Bellevue Hospital. Heliotherapy treatments were given, cod liver oil and iodid of iron.

Shortly after admission, September 14, he was examined by Dr. Miller, whose report was: The tip of the spleen can just be felt. The liver can easily be felt 2 inches (5 cm.) below the costal margin. The signs in the chest are confined to the lower posterior quadrant on each side. The appearance on the left is characteristic of chronic pleural adhesions. On the right, although the ribs are prominent, the percussion note is dull at the angle of the scapula, and in the axilla the breath sounds are slightly diminished. There are numerous discrete glands in the cervical region, particularly on the left and in both axillae, which are more characteristic of tuberculosis than of Hodgkin's disease.

On fluoroscopic examination, the right side of the diaphragm was high, but it moved moderately; on the left, there was localized density, somewhat elliptical, laterally between the third and seventh ribs; it seemed to be pleural and partly calcified. There was a shadow slightly less dense than the heart shadow to the left of the midline of the mediastinum, extending from the heart shadow to the clavicle. It seemed to be a distinct mediastinal shadow which did not bulge and did not pulsate except by transmitted pulsation. The appearance was that of mediastinal glands which may have suppurated.

The roentgen-ray report of September 8 was that there was a large mass in the median portion of the left upper lobe and hilum. The posterior medias-

tinum was clear. There was transmitted pulsation of this mass. The diagnosis was enlarged glands (?) or new growth (?). There was an effusion in the left pleural cavity, the upper level of which was at the seventh rib posteriorly.

On September 15, it was thought that a shifting fluid level could be seen under the fluoroscope. A diagnosis of tuberculous abscess of the mediastinum due to suppurating glands was made, and the patient was referred for operation.

September 21, a left posterior mediastinotomy with resection of the sixth and seventh ribs was performed. The pleura was separated from the sides of the vertebral bodies and the aorta exposed, together with the mediastinal pleura. Induration of the tissues and enlarged glands were found. The wound was closed without drainage.

On September 29, the wound broke open and from 4 to 5 ounces (118 to 148 cc.) of foul, brownish yellow pus was discharged. A finger was inserted, but no opening could be found leading across the aorta. Roentgenograms taken at this time showed complete clearing of the mediastinal abscess.

The patient died the same day.

ABSTRACT OF DISCUSSION

Dr. Hugh Auchincloss, New York: I have had confirmation of the truth of many of the statements, made not only in malignant tumors of the breast which spread to the mediastinum and thence along the different paths that Dr. Lambert has spoken of, but also in a case of inflammation which I shall cite briefly. A young baseball player slid and scratched the left thigh. He had it dressed on Wednesday. On Thursday he neglected it. On Friday he had it dressed. On Saturday he did not return to have it dressed. On Sunday chills developed; he became ill and went to the infirmary. On Monday he was brought to New York and entered the Presbyterian Hospital, with hemolytic streptococci in the blood. He was desperately ill, and on Wednesday he died. Besides the usual symptoms associated with hopeless sepsis, he had rigidity of the abdomen and signs of fluid and consolidation in both sides of the chest, and a disturbingly large area of dulness in the front of the chest. The two little wounds were not important and dried up. At autopsy there was fibrin in the peritoneal cavity and fluid throughout. No visceral source for this infection could be found. The lymph glands in both iliac regions were large and soft. No abscesses were found in these glands, but when the aorta and the vena cava were raised, a chain of lymph glands containing abscesses, some almost 1 cm. in diameter, were found. They contained pus and hemolytic streptococcus. This chain ran up the posterior abdominal wall into the chest along the route of the thoracic duct. On either side there was a hemolytic streptococcus pneumonia with fluid in the pleural cavities and in the pericardiac sac. The lymph glands along the posterior mediastinum still showed little abscesses. The most striking thing, however, was that just below the junction of the thoracic duct and the vein was a lymph gland that was discharging pus from an abscess directly into the duct. This pus in the duct was, of course draining directly into the vein. Thus, infection of the retroperitoneal and mediastinal spaces was started by a scratch in the thigh, and this was followed by peritoneal and serous cavity involvement. Drs. Lambert and Berry have shown this condition diagrammatically; this case would seem to be clinical confirmation of the truth and importance of their observations.

Dr. Howard Lilienthal, New York: I am grateful to Dr. Lambert for having shown these excellent anatomic pictures, but still more because he has demonstrated such a number of cases of suppurative mediastinitis that

have been treated surgically. These cases were formerly considered unusual —so rare that some years ago when I was studying the subject I could find few instances of mediastinotomy for suppuration. These cases resemble mediastinitis in the roentgenogram. Surgical diagnosis and treatment by these methods will doubtless save many lives.

DR. NATHAN W. GREEN, New York: Dr. Lerche at a previous meeting also presented anatomic pictures of mediastinal infections. Each year the general surgeon should be informed concerning this condition and given better methods of treating it.

DR. WILLIAM LERCHE, St. Paul: I have had a few more cases of mediastinal suppuration since my report of three years ago. The cases I shall report at this meeting may show the way mediastinal suppuration begins, that is, in the mediastinal lymph nodes, particularly the tracheobronchial nodes.

INFECTED MEDIASTINAL LYMPH NODES AS A SOURCE OF MEDIASTINITIS

WILLIAM LERCHE, M.D.
ST. PAUL

The mediastinal lymph nodes often become infected in diseases of the respiratory tract, and preeminently so the tracheobronchial groups, which, according to Most,[1] receive the lymphatics from the lungs, bronchi, the lower part of the trachea and its bifurcation. In whatever way the micro-organism enters the lung, whether by penetrating the bronchial mucosa near the hilum and spreading in the interstitial tissue and lymphatic system to the lung, as shown in the experiments on monkeys with streptococcus and pneumococcus by Blake and Cecil,[2] or hematogenously as demonstrated by Krause[3] in experiments with tubercle bacillus in guinea-pigs, the micro-organism ordinarily is carried off from the lungs and bronchi by the lymphatics to the tracheobronchial lymph nodes. The importance of the tracheobronchial nodes as a germ-harboring depot cannot be overestimated. It has repeatedly been shown that virulent micro-organisms may be present in these lymph nodes without any other demonstrable focus in the body.

Although an abscess of the tracheobronchial nodes may discharge into a bronchus and healing take place, there are a number of necropsies reported in the literature in which it was found that abscesses from suppurating lymph nodes had ruptured into one of the large blood vessels or into the heart and other organs in the mediastinum. Therefore, surgical measures for the proper drainage should be instituted as soon as diagnosis is made.

In order to be able to make an accurate diagnosis and to carry out the proper surgical treatment, a definite knowledge of the topography of the various groups of lymph nodes and their relation to the surrounding organs is essential, and each group will therefore be reviewed briefly with the case reports.

The tracheobronchial lymph nodes consist of three main groups (fig. 1) situated in the right, in the left and in the inferior tracheobronchial spaces as described by Sukiennikow.[4]

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1. Most, A.: Ueber die Topographie des Lymphgefaszapparates im kindlichen organismus und ihre klinische Bedeutung, Arch. f. Kinderh. **48:**, 1908.

2. Blake, F. G., and Cecil, R. L.: Pathology and Pathogenesis of Pneumococcus Lobar Pneumonia in Monkeys, Exper. Med. **31**:445-474 (April) 1920; Experimental Streptococcus Hemolyticus Pneumonia in Monkeys, ibid. **32**:401-426 (Oct.) 1920.

3. Krause, A. K.: Tuberculosis in the Guinea-Pig After Subcutaneous Infection, with Particular Reference to Tracheobronchial Lymph Nodes, Am. Rev. Tuberc. **4**:135 (May) 1920.

4. Sukiennikow, W.: Topographische Anatomie der bronchealen und trachealen Lymph drüsen, Berl. klin. Wchnschr., 1903, p. 316.

The right tracheobronchial space (fig. 2), containing from five to seven lymph nodes, is bounded below by the right pulmonary artery and the right main bronchus, to the left by the trachea and the ascending aorta, anteriorly by the superior vena cava, and to the right by the mediastinal pleura above and the azygos vein below. The space is narrower above on account of the course of the right vagus nerve posteriorly and the innominate artery to the left. In figure 3 is shown the arrangement of the lymph nodes in this space.

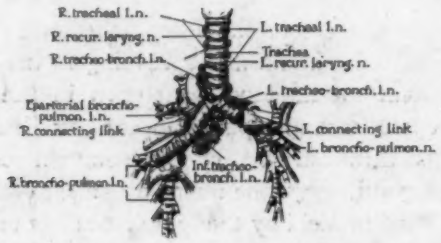

Fig. 1.—The tracheobronchial lymph nodes (Sukiennikow).

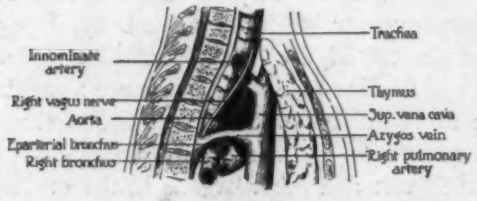

Fig. 2.—The right tracheobronchial space (Sukiennikow).

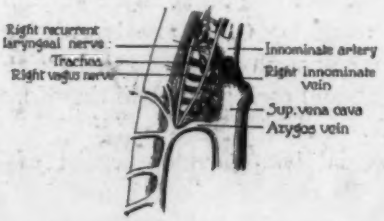

Fig. 3.—The right tracheobronchial group of lymph nodes (Sukiennikow).

REPORT OF CASES

Case 1.—A farmer, aged 46, weighing 180 pounds (81 Kg.), had had pleurisy at the age of 31, with good recovery, and a severe attack of influenza at the age of 39. Since the attack of influenza he had been troubled with a dry hacking cough and frequent "colds." About three months prior to consultation, he had noticed pain in the upper part of the chest behind the sternum and to the right. Two months later, the pain had become severe and had radiated throughout the upper part of the right side of the chest, increasing in severity on coughing, deep

breathing or walking. Pain also had been felt between the shoulders, but had not been so severe. The dry cough had become worse, and he had had frequent frontal headaches accompanied by nausea and occasional vomiting. He had had pain on swallowing and, occasionally, dysphagia and dyspnea. He had had a feeling of pressure in the chest, a choking sensation and palpitation of the heart on slight exertion. He had had to sleep with the head and shoulders high. All these symptoms were less pronounced at the time of consultation than they had been three weeks before.

Inspection revealed swelling in the region of the right second costal cartilage and in the first and upper part of the second interspace. On palpation this area

Fig. 4 (case 1).—Mediastinal abscess, *a*, *a*.

was found sensitive. Auscultation was negative, except for roughness of breath sounds over the larger bronchi on the right side. Percussion revealed dulness over the sternum and the area in the first and second right interspace. The leukocyte count was 5,600; the temperature, 97.4; the pulse, 80, and respiration, 30. Fluoroscopic examination showed an abnormal shadow in the upper part of the chest behind the manubrium, in the upper part of the sternum and through posteriorly beyond the arch of the aorta to the spinal column, as seen in figure 4. On bronchoscopic examination, the first part of the right main bronchus and the adjoining part of the trachea were red, inflamed and somewhat edematous. There

was no evidence of compression of the esophagus as seen through the esophagoscope. The diagnosis was mediastinal abscess due to suppuration of the right tracheobronchial group of lymph nodes.

Anterior mediastinotomy for drainage was advised, but the patient insisted on postponing the operation for a few days. Twenty-four hours later, he had a violent attack of coughing and expectorated about a pint of pus. Bronchoscopic examination, made three days after the discharge of the abscess, disclosed a dark recess on the anterior wall of the trachea to the right near the bifurcation, which evidently was the avenue of exit for the pus. The leukocyte count at this time was 9,800. All symptoms had disappeared, and the patient felt well. A culture from the pus showed mainly pneumococcus. Tests on guinea-pigs that were inoculated were negative for tuberculosis. It was by the aid of the bronchoscope that the diagnosis could be clinched in this case by observing the inflamed condition of the mucosa at the right tracheobronchial angle, corresponding to the anterolaterally situated group of lymph nodes in the right tracheobronchial space. The fact that all symptoms were less severe at the time of consultation than they were three weeks earlier was probably due to the escape of the pus from the narrow confines of the tracheobronchial space, which

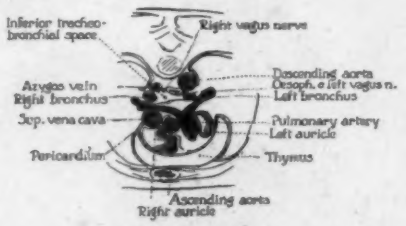

Fig. 5.—The inferior tracheobronchial space seen from above: cross section of fourth and fifth dorsal vertebrae (Sukiennikow).

relieved the pressure on the organs forming its walls. It will be noticed that although the patient had pain on swallowing, he experienced only occasional dysphagia, due probably to pressure on the vagus, which forms a part of the posterior boundary in the right space. He had only occasional dyspnea, because, although there was pressure on the tracheobronchial angle and there was some edema of the mucosa, the bronchial tube was not compressed, as seen by bronchoscopic examination. There was pressure on the vessels. The abscess in this case pointed forward, and I proposed to drain it through an anterior mediastinotomy. On the other hand, an abscess in this space might extend upward between the right carotid artery, the trachea and the spinal column and be drained through the neck or through a posterior mediastinotomy.

The inferior tracheobronchial space (figs. 1 and 5) contains from nine to twelve lymph nodes and is bounded anteriorly by the pericardium; laterally and above, by the two main bronchi and the bifurcation; posteriorly to the left, by the esophagus, and posteriorly to the right, by the dorsal vertebrae and the vessels and nerves placed on them; below, the space extends to the level where the pulmonary veins enter the left auricle.

CASE 2.—A woman, aged 24, had had influenza accompanied by pneumonia in 1918. Since the attack she had been troubled with a dry cough and frequent "colds." In May, 1921, she had had a chill and had noticed pain in the chest substernally, which increased on deep breathing and on swalllowing either liquids or solids. She had dyspnea and dysphagia. The temperature for several days did not rise above 100. Her condition grew gradually worse and ten days later the pain in the chest became severe, and was also felt in the back between the shoulder blades. Hiccup developed. The temperature was 102.6. The dysphagia increased to such an extent that the patient could hardly swallow liquids and the dyspnea became extreme. The patient then had a severe coughing spell and

Fig. 6 (case 2).—Anteroposterior view: *a*, bifurcation; *b*, right bronchus; *c*, left bronchus; *d*, *d*, *d*, abscess in inferior tracheobronchial space; *e*, *e*, *e*, esophagus, and *f*, trachea.

expectorated three-fourths pint (354 cc.) of pus, with immediate relief. The highest leukocyte count was 30,200. In this case, the abscess originated in the lymph nodes of the inferior tracheobronchial space, where both main bronchi as well as the bifurcation were exposed to the pressure of the pent up pus, and the esophagus, as shown in the roentgenograms, was compressed to the almost complete occlusion of its lumen. In the anteroposterior view (fig. 6), a narrow streak of barium was seen to the left. In the oblique view (fig. 7), the column

of barium appeared as a thin broad band. The right part of the posterior boundary of this space (the spinal column) was on a plane posteriorly with the left part of the posterior boundary (the esophagus), permitting the latter to be compressed laterally from right to left.

In cases 1 and 2, the dry hacking cough has ceased since the discharge of the abscesses.

I feel certain that if bronchoscopic and esophagoscopic examination had been carried out in this case, there would have been no difficulty in

Fig. 7 (case 2).—Oblique view of abscess, *a, a, a, a;* of esophagus, *b, b.*

establishing a definite diagnosis. A posterior mediastinotomy would be the method of choice in draining the abscess in this case.[5]

The left tracheobronchial space (fig. 8) contains from three to six lymph nodes. Its boundaries are, posteriorly, the esophagus and the descending aorta; to the left, the ductus arteriosus; to the right,

5. This case occurred in the practice of Dr. E. V. Goltz of St. Paul, who allowed me to study the history and the roentgenograms.

the trachea; below, the left tracheobronchial angle, and above, the aortic arch.

Case 3.—A child, aged 3 months, one of twins, apparently had been well until the age of 6 weeks, although it had always been somewhat paler than its twin. Since the age of 6 weeks, it had not taken its feedings so well, and had ceased gaining in weight. Since the age of 7 weeks, it had been hoarse and had

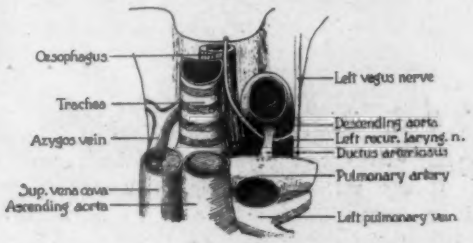

Fig. 8.—The left tracheobronchial space (Sukiennikow).

Fig. 9 (case 3).—Atelectasis of left lung due to pressure on the left bronchus.

wheezed and coughed. It coughed at each feeding and had frequent regurgitation. While in the hospital, the nurse noticed that when the baby was picked up it cried as if in pain, became cyanotic about the nose and mouth and coughed. There was always a great deal of mucus in its throat. Tube feeding was tried, but unless the tube was introduced toward the right, it met with an obstruction

in the esophagus and could not be passed. At times the baby became cyanotic on the introduction of the tube. On being fed with a spoon, the baby cried at every swallow. The temperature was 100. The result of a Pirquet test was negative. A roentgenogram of the chest had been taken, and a diagnosis of malignant growth of the left lung with fluid in the pleural cavity had been made.

I saw this patient in consultation four days before death. Another roentgenogram of the chest was taken (fig. 9). My diagnosis was atelectasis of the left lung, due either to pressure on the left main bronchus by enlarged lymph nodes in the left tracheobronchial space or to a foreign body in the left bronchus with edema, or possibly a growth at the hilum. An endoscopic examination was not made, as the patient's condition was poor.

At necropsy atelectasis of the left lung was seen. The heart was large; there was left-side hypertrophy, with slight hypertrophy of the right side of the heart. The left auricle was considerably dilated, with marked thinning of the wall of the apex. The valves were normal. The ductus arteriosus and foramen ovale were closed. There was an anomaly of the coronary system, the left coronary artery rising from the pulmonary artery instead of the aorta. The anomalous coronary had the distribution of the normal left coronary artery. The right and the inferior groups of the tracheobronchial lymph nodes were

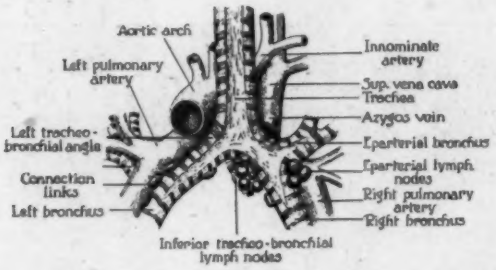

Fig. 10.—Posterior view of trachea; eparterial lymph nodes.

not enlarged, while the left group formed a large mass the size of a lima bean, and the chain of lymph nodes along the left side of the trachea showed considerable enlargement. The large mass of lymph nodes noted undoubtedly exerted pressure on the left main bronchus, being between the latter and the aortic arch above, while the enlarged heart, according to the pathologist's report, pressed on the left bronchus from below. The left recurrent nerve, which is usually in close contact with the left tracheobronchial lymph nodes (fig. 18), was exposed to pressure, hence the pronounced hoarseness. The esophagus forms the right part of the posterior boundary and is also exposed to pressure. Microscopic examination revealed hyperplasia of the left tracheobronchial lymph nodes. Unfortunately, a bacteriologic examination of the affected lymph nodes was not made. On cadavers I have tried the approach to the left tracheobronchial space, both through an anterior as well as a posterior mediastinotomy, and it seems as if the anterior route would be the easier.

In order to demonstrate the effect of pressure on a bronchus by enlarged lymph nodes, I report case 4. The ventral eparterial bronchopulmonary group contains from three to four lymph nodes situated at the angle of the eparterial bronchus (fig. 10).

Fig. 11 (case 4).—Atelectasis of upper right lobe.

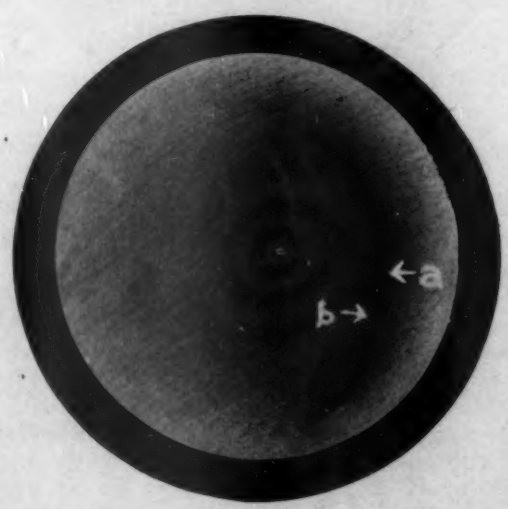

Fig. 12 (case 4).—Bronchoscopic view of compressed eparterial bronchus: *a*, upper wall; *b*, lower wall.

Case 4.—A child, aged 10 months, developed cough with a peculiar stridor so suddenly that it was thought that a foreign body had entered a bronchus. Roentgenograms (fig. 11) showed enlarged bronchopulmonary and tracheobronchial nodes, atelectasis of the upper right lobe and overdistention of the lower lobes. Through the bronchoscope, I saw the lower wall of the eparterial bronchus pushed against its upper wall so as to obliterate the passage (fig. 12). A mass of tuberculous lymph nodes of the eparterial group was the cause of complete obstruction of the upper lobe bronchus and partial obstruction of the lower lobe bronchus.

Bartels,[6] quoting W. Krause, states that the posterior mediastinal lymph nodes, from eight to twelve in number, lie on the thoracic aorta and the esophagus.

Fig. 13 (case 5).—Fistulous opening in esophagus.

According to Sakata,[7] the posterior mediastinal lymph nodes are scattered around the thoracic aorta, from the level of the tracheal bifurcation to the hiatus oesophageus.

Case 5.—A woman, aged 26, complained of cough following an attack of influenza with pneumonia three years previously. The cough had increased, and for several months before the consultation she had noticed purulent expectoration and also that a part of the liquids that she took were coughed up. Occasionally, the expectoration had been blood streaked.

Esophagoscopic examination revealed an opening in the wall of the esophagus, posteriorly to the right, communicating with a cavity in the mediastinum, which was filled with bits of an apple that she had eaten the day before and which I

6. Bartels, P.: Das Lymphgefässsystem, Jena, 1909.

7. Sakata, K.: Ueber die Lymphgefässe des Oesophagus und über seine regionären Lymphdrüsen mit Berücksichtigung der Verbreitung des Carcinoms, Mitt. a. d. Grenzgeb. d. med. u. chir. **11**:634, 1903.

Fig. 14 (case 5).—Anteroposterior view: *a*, abscess cavity in posterior mediastinum: *b*, fistula to the esophagus; *c*. *c*. barium mixture in bronchi, and *d*, fistula to the right lung.

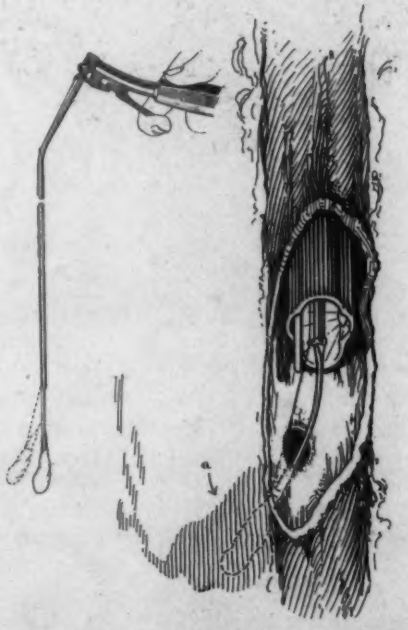

Fig. 15 (case 5).—Method of making applications to the mediastinal abscess cavity, *a*, through the esophagoscope.

removed. The opening was situated in the upper part of the lower third, it was almost circular in outline (fig. 13) and the margin was well covered with epithelium, indicating that it had been present some time. On fluoroscopic examination with a barium mixture, the latter was seen to pass through the fistulous opening in the esophagus and, having filled the cavity in the posterior mediastinum, enter the right lung, and ascending through the bronchi to be finally coughed up (fig. 14).

In this case, lymph nodes in the posterior mediastinum, which drain the esophagus as well as the mediastinal pleura, had probably become infected from

Fig. 16 (case 6).—Abscess cavity in mediastinum, *a*, and fistula to esophagus, *b*.

the right pleura during the attack of influenza, the abscess ulcerating into both the esophagus and the right lung. In figure 15 is shown the method by which the cavity was treated by the application of silver nitrate solution or tincture of iodine twice a week through the esophagoscope. After a few weeks of treatments, the cough ceased, and the patient did not expectorate any of the ingested liquids. The cavity apparently was getting smaller, and her general health improved. However, the patient did not return for further treatment, so I did not have the opportunity to see the ultimate result of this treatment. My plan was later to cauterize the mucosa of the opening with actual cautery through the esophagoscope.

CASE 6.—A man, aged 72, had been in good health until six weeks before consultation, when a piece of meat had become impacted in the lower part of the esophagus. The meat finally had been regurgitated, but since the accident the patient had had pronounced dysphagia and a great deal of pain in the lower part of the left side of the chest, radiating to the back, with hiccup and nausea but no vomiting.

Through the esophagoscope, I saw a small ulcerating growth in the lower third of the esophagus, posteriorly to the right, with an opening in the center from which pus exuded. Biopsy showed adenocarcinoma. A roentgenogram (fig. 16) showed a cavity in the posterior mediastinum communicating with the esophagus. These observations were corroborated by necropsy. The presence of

Fig. 17 (case 7).—High position of left side of diaphragm.

the meat probably favored infection that was carried to the lymph nodes in the posterior mediastinum; an abscess formed and broke through the center of the small carcinoma in the esophageal wall.

The preaortic lymph nodes are situated on the anterior surface of the aortic arch.

CASE 7.—A girl, aged 16 years, had had a cough for two weeks when seen in May, 1920. There was a friction rub over the pleura on the left. The chest was examined fluoroscopically, and the diaphragm was seen functioning normally. In March, 1921, she had repeated attacks of hiccup and pain behind the upper part of the sternum. She also complained of a choking sensation and fulness after taking even small amounts of food. On fluoroscopic examination, the left

side of the diaphragm was seen to be on a considerably higher level than the right (fig. 17); on expiration, it reached the upper border of the fourth rib. The condition improved, and five months later the left side of the diaphram was on a lower level, but was not quite normal. In March, 1922, she had pleurisy on the left side, and the left side of the diaphragm in full expiration extended to the middle of the third rib.

The patient later developed tuberculosis of the apex on the left, and there was thickening of the pleura on the left. Her present state of health is apparently good. A recent fluoroscopic examination, more than five years after the insufficiency of the diaphragm was first noticed, showed the left side of the diaphragm 2.5 cm. below the right in deep inspiration, and less than 1 cm. above the right side of the diaphragm in full expiration.

The left phrenic nerve is in close proximity to the preaortic group of lymph nodes, and I believe that infection of these nodes with a periadenitis involving the phrenic nerve was the cause of the insufficiency of the left side of the diaphragm in this case. Figure 18 shows a sketch from a cadaver in which the phrenic nerve was firmly adherent to the preaortic lymph nodes. Such cases of nonsuppurative mediastinitis are

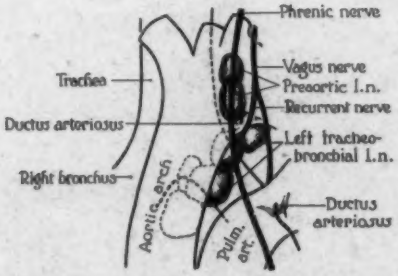

Fig. 18 (from cadaver).—Left phrenic nerve adherent to preaortic lymph nodes. The left recurrent nerve is seen between lymph nodes in the left tracheobronchial space.

probably not infrequent. Dorendorf [8] reported the case of a woman, aged 64, with pneumonia on the left side, who developed hoarseness due to paralysis of the left recurrent nerve. Necropsy revealed the left recurrent and the left vagus nerves surrounded by a gelatinous edema, and there were many swollen tracheobronchial lymph nodes.

CASE 8.—A woman, aged 37, had had suppurating cervical lymph nodes in her youth. At the age of 25, by accident a bit of cornflake had entered the larynx, precipitating a violent attack of coughing, with choking. Thereafter, whenever she took liquids, part was coughed up. She had regurgitation of food and thick mucus, epigastric pain, distress and vomiting, and she could not lie on the right side without pain or vomiting. Dyspnea was marked, increasing on exertion.

8. Dorendorf: Die Diagnose akutennicht eitrigen-und der chronischen Mediastinitis, Arch. f. Laryngol. u. Rhinol. **33**:285-293, 1920.

Fluoroscopic examination showed that the upper limit of the left side of the diaphragm was on a level with the third interspace, the fundus of the stomach was distended by an enormous gas bubble, and the heart was displaced to the right (fig. 19). When the patient swallowed the barium mixture, part of the latter was seen flowing into the bronchi on both sides. This phenomenon was due to an esophagotracheal fistula (fig. 20). The fistula was found to be 19 cm. from the incisor teeth, as measured in bronchoscopy and esophagoscopy. I believe that in this case the insufficiency of the left side of the diaphragm, the so-called eventration, was acquired and due to degeneration of the left phrenic nerve following inflammation of the nerve by extension from infected lymph

Fig. 19 (case 8).—Left side of diaphragm, *a*, and barium mixture in bronchi, *b*, *b*. *b*.

nodes, probably the preaortic group. The esophagotracheal fistula was caused by suppurating tracheal lymph nodes ulcerating through the walls of the esophagus and trachea, the abscess rupturing during the violent coughing spell.

I made a phrenoplication of the left side of the diaphragm (fig. 21), which relieved the patient of her dyspnea and gastric symptoms; for a while she coughed less. In time, the cough became more troublesome, and I attribute this to the fact that the fistula on the esophagus side, which originally had two openings, separated by a narrow strip of esophageal mucosa, became converted into

one large oval opening by the sloughing off of the intervening strip of mucosa; this facilitated the entrance of food into the trachea. For that reason, four years after the phrenoplication, I made an anterior mediastinotomy by raising a flap containing the left part of the sternum down to the second interspace, the clavicle and the first and second rib, as described by Le Fort.[9] I loosened the adhesions down to the fistula without opening the latter. To repair the fistula did not seem feasible, and the chest was closed. During the year following this operation, the patient was in better health, her weight increased to 145 pounds (65 Kg.), and she coughed less. To what this improvement can be ascribed, I

Fig. 20 (case 8).—Esophagotracheal fistula, *a*.

do not know, unless that postoperative adhesions, by contraction, had decreased the fistulous opening or distorted it in such a way that food did not enter the trachea as readily as before.

One year after the last operation, she had an attack of influenza, after which severe cough developed with gradually increasing purulent expectoration, abdominal distress and vomiting. The vomiting gradually increased, and seven months later she could retain hardly any food. An exploratory laparotomy was made. Extensive adhesions were found in the right epigastric region between

9. Le Fort, R.: Une voie économique et large pour l'acces du carre-four cervico-médiastinal. Presse méd. **26**:373 (July 22) 1918.

the stomach, liver, omentum, coils of the intestines and the anterior abdominal wall. A gastro-enterostomy gave no relief.

Necropsy was performed by Prof. E. T. Bell. Except for the adhesions mentioned, no lesion of the abdominal organs was found. The diaphragm reached the fourth rib on the right and the fifth rib on the left. The left pleural cavity was obliterated by adhesions. The tracheobronchial and other mediastinal lymph nodes were markedly enlarged on the left side, but normal on the right. There were adhesions in the upper part of the mediastinum. There was no gross evidence of tuberculosis of the lungs, but there was bronchiectasis of the lower left lobe. The esophagotracheal fistula was oval and measured 10 by 6 mm. The extensive adhesions in the right upper abdominal quadrant, in the absence of organic lesions or surgical intervention in this region and with the symptoms coming on

Fig. 21 (case 8).—Phrenoplication.

after the attack of influenza, may be ascribed to infection after influenza. The diaphragm was removed in its entirety. On gross inspection, no trace of the phrenoplication was seen. The left side of the diaphragm had held its place since the operation, and the patient thereby had been relieved of distressing symptoms.

Dalziel [10] reported a case of a large abscess from tuberculous lymph nodes under the arch of the aorta in which he had successfully operated, and he refers to two similar cases of his in which operation was performed with satisfactory results. These abscesses probably originated in the preaortic in the tracheobronchial lymph nodes on the left.

10. Dalziel, T. K.: Tuberculous Glands in the Anterior Mediastinum; Operation, J. Laryngol. Rhinol. & Otol., 1915, p. 83.

The ulceration of suppurating tuberculous tracheobronchial lymph nodes into the trachea or bronchi is not rare. Schaldemose [11] compiled nineteen cases from the literature prior to the year 1900 and reported a case of his own. Schmiegelow [12] compiled twenty cases since the year 1900 and reported three cases of his own.

In this type of case, immediate bronchoscopy is indicated for the purpose of diagnosis and for the removal of the débris from the caseous lymph nodes obstructing the respiratory passage. Schmiegelow also reported the case of a baby, aged 8 months, who died from an obstruction in the respiratory tract. Necropsy revealed a hyperplastic lymph node the size of a walnut compressing the trachea.

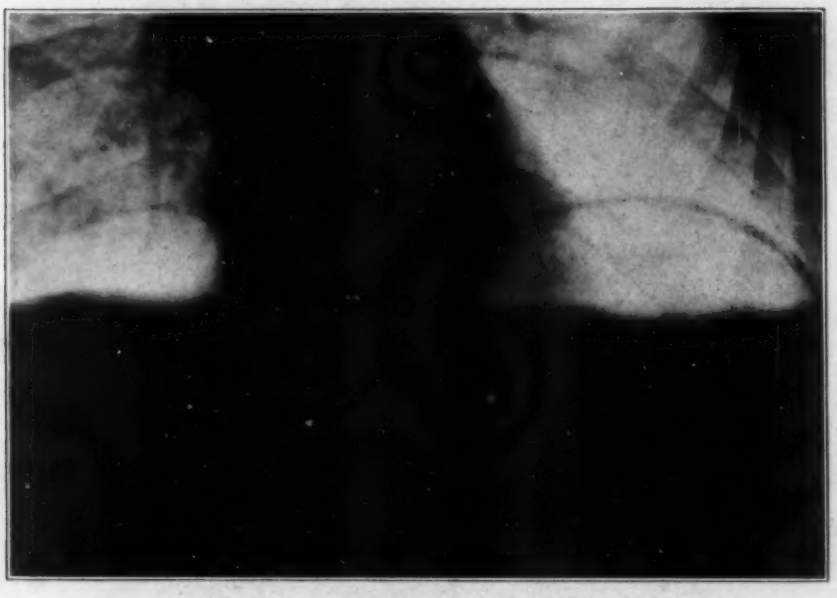

Fig. 22 (case 9).—Insufficiency of the left side of diaphragm.

In cases 1, 2 and 5, the patients dated the beginning of their trouble back to an attack of influenza. Although the literature on this question is scant, I believe that cases of mediastinal infection due to suppurating mediastinal lymph nodes, during and following the great epidemics of influenza, must have been of relatively frequent occurrence. This seems to be borne out by the observations of Dunham.[13] On examining the

11. Schaldemose, V.: Et tilfaelde af bronchialglandeltuberkulose med perforation, helbredet ved tracheotomi, Hospitalstid. **14**:22, 1902.

12. Schmiegelow, E.: Bidrag til bronchialglandeltuberculosens pathologi, Hospitalstid. **61**:5, 1918.

13. Dunham, E. K.: Infection in the Mediastinum in Fulminating Cases of Empyema, Surg. Gynec. Obst. **25**:288 (Sept.) 1922.

records of 3,889 cases of nontraumatic empyema in the United States Army, he found that sixty-seven cases of acute mediastinal infection had been noted in 531 necropsies. Many of these cases were associated with postinfluenzal and postmeasles empyema. Routine examination of the mediastinal lymph nodes apparently had not been made, but he mentions one case thus examined and in that streptococcus was demonstrated.

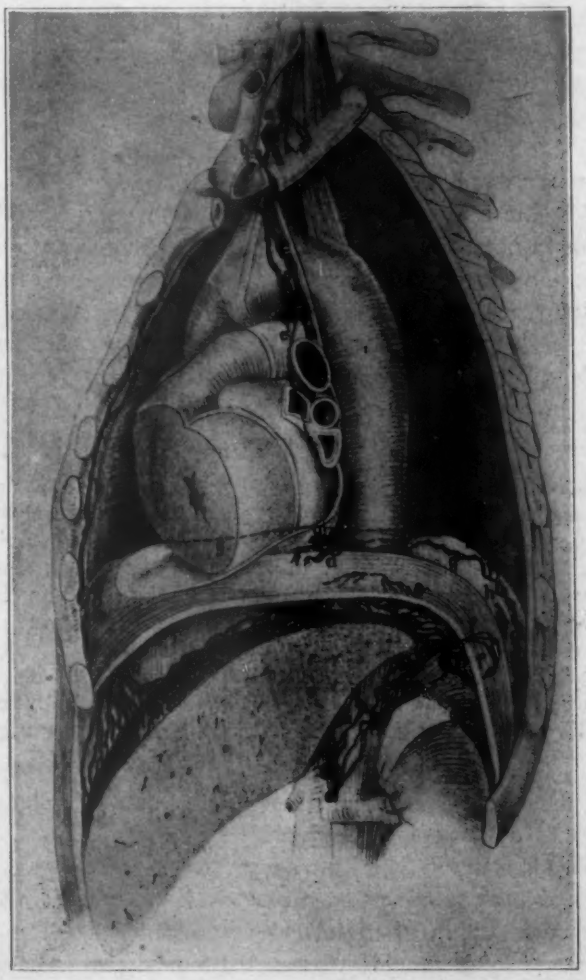

Fig. 23 (case 9).—Lymph nodes, *c c*, on the left phrenic and vagus nerves and the aorta.

Dunham also mentions a case of empyema on the right with purulent pericarditis, the latter secondary to mediastinitis. At the tracheal bifurcation was a mass of glands about the size of two fists, from which a tract led to the pericardium, which held a quart (946 cc.) of pus.

What part infected tracheobronchial or bronchopulmonary lymph nodes compressing a bronchus play in the etiology of bronchiectasis, and what part they play in the etiology of lung abscess, is well worth serious consideration.

In cases 7, 8 and 9 the diaphragm was affected. In each case, it was due to infected lymph nodes giving rise to acute nonsuppurative mediastinitis, which involved the left phrenic nerve. In an article published in 1922,[14] I classified cases of this condition of the diaphragm as congenital and acquired cases, subdividing the latter into acute and chronic, and I suggested the name "insufficiency" of the diaphragm instead of the name "eventration." Insufficiency means incapacity for normal action, while the name eventration of the diaphragm has no reference to the condition of the diaphragm itself. In case 9, I saw the left side of the diaphragm in the normal state, in the acute stage of insufficiency and in its return to normal. In case 7, I saw the diaphragm when normal, and also in the acute stage, but it had not returned to normal when observed five years later. In case 8, the insufficiency was chronic.

Under the name anterior mediastinodiaphragmatic lymph nodes, Bartels [6] describes the lymph nodes situated where the phrenic nerve enters the diaphragm and a group of nodes near the inferior vena cava. These nodes receive lymph vessels from the liver and the diaphragm.

Case 9.—A man, aged 38, had been doing well after a posterior gastroenterostomy for duodenal ulcer and an appendectomy, until the eighth day after the operation, when he felt nauseated and had an emesis. On the ninth day, hiccup developed and continued for three days, at times severe. The nausea and the vomiting ceased three days later. The patient was discharged on the nineteenth day after the operation. The temperature at no time exceeded 100 F. On fluoroscopic examination, the left side of the diaphragm was seen at a higher level than the right (fig. 22), and on expiration it reached the third interspace. This condition of the diaphragm lasted several weeks; it gradually came down to the normal level in about eight weeks after the onset. Roentgenograms taken before the operation showed a normal diaphragm.

Subdiaphragmatic infection occasionally follows abdominal operations, especially operations on the vermiform appendix. As the anterior mediastinodiaphragmatic lymph nodes receive lymph from the liver and the diaphragm and are close to the phrenic nerve where this enters the diaphragm, an infection of these nodes with a localized acute nonsuppurative mediastinitis would involve the nerve and account for the condition of the left side of the diaphragm. There is, however, another avenue by which infection from the abdomen may enter lymph nodes in close contact with the phrenic nerve. Küttner,[15] in injecting the lymph

14. Lerche, W.: Insufficiency (Eventration) of the Diaphragm, Surg. Gynec. Obst. **34**:224-229 (Feb.) 1922.

15. Küttner, H.: Die perforierenden Lymphgefässe des Zwerchfells und ihre pathologische Bedeutung, Beitr. z. klin. Chir. **40**:136, 1903.

vessels of the falciform ligament of the liver in a cadaver, found that although some of the vessels ended in the supraclavicular lymph nodes, the majority turned into the mediastinum at the level of the first rib, and after passing through a lymph node lying on the phrenic nerve crossed the triangular space between the latter and the left vagus, where they ended in a large lymph node on the aorta and the anterior aspect of the vagus (fig. 23 *c, c*). An inflammation of these nodes might give rise to an acute nonsuppurative mediastinitis affecting the phrenic nerve. Although the latter route of the infection from the abdomen by way of the subdiaphragmatic space is possible, I believe that the infection of the phrenic nerve in this case took place through the anterior mediastinodiaphragmatic nodes.

CONCLUSIONS

1. There is considerable discrepancy in the anatomic literature in regard to the topography, the number and the nomenclature of the mediastinal lymph nodes.

2. The mediastinum seems remarkably tolerant to infection.

3. The bronchoscope and the esophagoscope are of great aid to the thoracic surgeon in diagnosis as well as treatment; in the diagnosis of suppuration in the tracheobronchial spaces referred to in the foregoing they are indispensable.

4. I believe that the future specialist in thoracic surgery will find it necessary to be an expert in bronchoscopy and esophagoscopy.

ABSTRACT OF DISCUSSION

DR. EDWARD W. ARCHIBALD, Montreal: The reports made by Dr. Lerche in the last two or three years indicate that he is qualified to teach precision in diagnosis of obscure conditions in the mediastinum and their anatomic situation. Some years ago when I had a case of this kind, I was confused, and I found that every one else was as confused about mediastinal infections and abscess as I was. I had one case, which I think I mentioned when Dr. Lerche read his last paper on the subject, in which the communication made by the breaking through of an abscess was betrayed by a gas bubble rising above the shadow; this, of course, was caused by the abscess in the neck. This abscess was not only in one but in both sides of the neck.

HERNIAS OF THE MEDIASTINUM DURING THE COURSE OF ARTIFICIAL PNEUMOTHORAX

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When air gains access to the pleural cavity a displacement of the mediastinum frequently takes place. This mobility of the mediastinum depends on the flexibility of its tissues, the lack of pleural or pleuropericardial adhesions, the pressure created within the pleural space and the size or volume of the pneumothorax. The entire mediastinum may be shifted or a part of it. Thus, only the upper or only the lower portion of it may be displaced. Besides these variations in the position of the mediastinum, a protrusion of the pneumothorax cavity through the mediastinum into the sound, or untreated, side, occasionally takes place, thus forming a culdesac, or hernia. The most frequent point for a hernia of this nature to occur is in the upper anterior part of the mediastinum between the first and third ribs. Here the right pleura and the left pleura come in closest contact and are separated only by a slight amount of areola tissue; the junction represents the weakest point in the mediastinal barrier. The lower posterior part of the mediastinum between the fifth and the tenth dorsal vertebrae is another weak spot.

The hernia may be small and protrude only slightly into the sound side, or so large as to form a distinct localized pneumothorax.

The cases reported here illustrate the various types of mediastinal hernia.

REPORT OF CASES

CASE 1.—H., a man, aged 34, had had the right lung successfully collapsed by artificial pneumothorax in February, 1924. The mediastinum had been mobile. There had been no effusion and the clinical results had been excellent. The average refill had been 600 cc. every two weeks. The average pressure before refill had been -6 -3; after refill, $0+2$. After one year of collapse therapy, the patient had complained of pain in the upper part of the left side of the chest and some shortness of breath shortly after the administration of gas.

Examination showed dull tympany over the entire right side of the chest and extending 1 inch (2.5 cm.) beyond the left margin of the sternum in the region of the second rib. The area was devoid of breath sounds. The left border of this zone was defined by the exaggerated respiratory sounds of the left lung. On fluoroscopic examination, a high light was seen extending about 2 inches (5 cm.) beyond the left border of the sternum, its clearly defined edge describing an arc from the first to the third rib. On deep inspiration, the high light moved toward the pneumothorax side and became lost in the shadow of the mediastinum, only to reappear on expiration. This to-and-fro movement of the hernia during respiration is a startling fluoroscopic picture.

The discovery of the hernia led to a reduction in the amount of gas administered, and as a consequence the hernia gradually disappeared. The vesicular murmur of the sound left lung is now heard to the midline of the sternum.

CASE 2.—N., a man, aged 24, had had the right lung well collapsed by artificial pneumothorax in April, 1923. The mediastinum had been mobile. The average refill had been 700 cc. every three weeks. The pressure before refill had been —6 —4; after refill, —3 —1. In January, 1924, he had developed a slight pleural effusion without local or constitutional symptoms. In February, 1924, a

Fig. 1 (case 1).—Small hernia of the mediastinum during forced expiration. Comparison should be made with figure 2.

mediastinal hernia was first noted between the first and the third ribs, and at this time shortness of breath occurred. The hernia was larger than the one observed in the previous case, and contained a small amount of fluid. This hernia showed a to-and-fro movement but did not entirely disappear at the height of inspiration. With a reduction in the amount of gas administered, the dyspnea was relieved and the hernia soon disappeared.

CASE 3.—H., a man, aged 29, had had the right lung collapsed by artificial pneumothorax in October, 1923. The mediastinum had been mobile. The average refill had been 700 cc. every two or three weeks. The pressure before

refill had been —7 —3; after refill, —3 —1. In March, 1924, the patient had developed a pleural effusion. It was ushered in with severe symptoms, pains in the right side of the chest, fever, vomiting and urgent dyspnea. On March 15, 600 cc. of turbid fluid had been withdrawn.

On entrance, the pressure above the level of the fluid was + 1 to + 3. After paracentesis and replacement with air, the pressure was left at —5 to 0. Two weeks later, a roentgenogram of the chest showed a fairly well collapsed right lung and the mediastinum moderately displaced; between the first and fifth ribs

Fig. 2 (case 1).—Outline of hernia not seen, during full inspiration. The swing of the mediastinum and the collapsed lung should be noted in comparison with figure 1.

a well defined hernia bulged into the left side of the chest in front of the heart and trachea. A fluid level was seen at the fifth rib on the right and extended over into the hernial sac.

The physical signs usually elicited over a pneumothorax extended across the sternum into the left side of the chest over the zone of the hernia. Succussion sounds were heard in the normal cardiac area.

While the hernia existed, the patient had marked dyspnea, a rapid pulse, uncomfortable cardiac sensations and pain beneath the lower part of the sternum radiating to the back. By the occasional aspiration of fluid and replacement with

small amounts of air, the symptoms were gradually ameliorated. In August, 1924, roentgen-ray examination showed that the mediastinum occupied its normal position and that the hernia had entirely disappeared. It is interesting that in this case the pleural pressures were never found above + 3. Usually, they were less than zero.

Brauer [1] reports a case in which the hernia involved the lower posterior part of the mediastinum. The pneumothorax was on the right side,

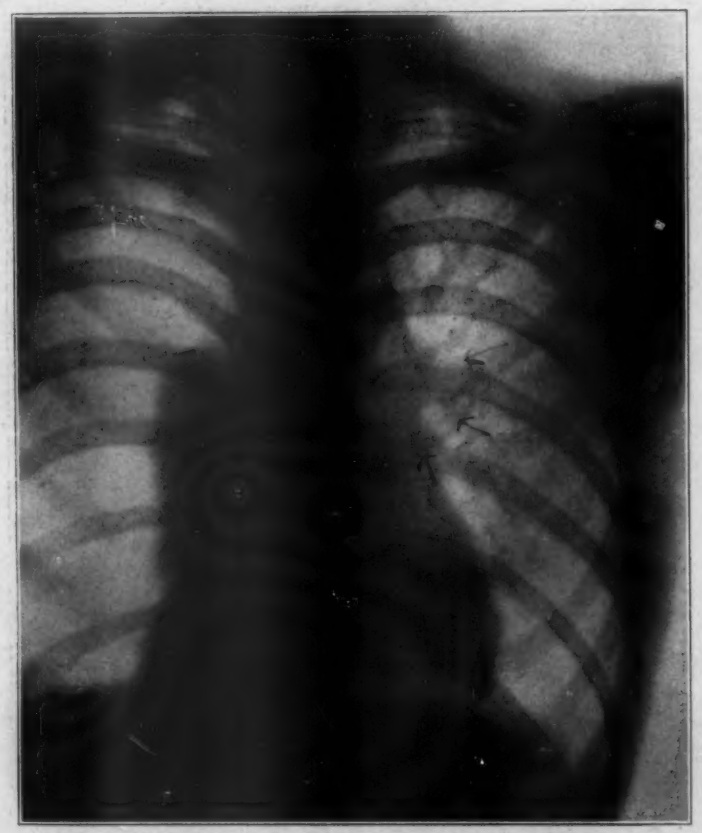

Fig. 3 (case 2).—Medium sized mediastinal hernia containing small amount of fluid.

the culdesac to the left. The fluid level of an effusion crossed in front of the spinal column. This hernia is the only one I have found reported that occurred at this site.

Brauer and Spengler [2] report a case of von Muralt's of a large, pouchlike hernia containing fluid. When the patient was tipped to the

1. Brauer: Handbuch der Tuberculose, ed. 3, vol. 2, p. 489.
2. Brauer and Spengler: Beitr. z. Klin. d. Tuberk. **19**:1, 1911.

right, the fluid ran from the hernia into the pneumothorax side, the neck of the sac being in front of the great vessels of the heart. My case 2 was like von Muralt's, but the hernia and the exudate did not attain such large proportions.

Kellner [3] describes a case in which at necropsy two large culdesacs of a left-sided pneumothorax were found bulging in front of the heart into the right side of the chest. An exudate was present. It was

Fig. 4 (case 3).—Large hernia of the anterior part of the mediastinum.

thought that the hernia was the cause of death—by embarrassing the heart action and limiting the function of the sound lung. My case 3 was somewhat similar, the patient had cardiac and respiratory distress but escaped death.

Eggers [4] has recently reported a case of pyopneumothorax which pushed through the anterior mediastinum to form an enormous hernia

3. Kellner: Beitr. z. Klin. d. Tuberk. **54**:405, 1923.

4. Eggers, Carl: Lung Abscess Complicated and Hidden by Empyema, Arch. Surg. **12**:338 (Jan.) 1926.

in the left side of the chest. A roentgenogram of the patient taken in the erect position, but inclined to the right, showed the fluid level running across the entire thorax.

SUMMARY OF REPORTED CASES

A review of the thirty-nine cases of mediastinal hernia, including nine of my own, reported in the literature shows:

Fig. 5 (case 3).—Posterior view, showing exaggerated appearance of hernial sac.

1. That in only one instance was the lower part of the mediastinum involved posteriorly, the rest being involved anteriorly—thirty-four between the first and third ribs, and four between the first and fifth ribs.

2. In twenty-four cases, the pneumothorax was left-sided, the hernia being to the right; in fifteen, the pneumothorax was on the right side and the hernia to the left.

3. In all cases, the mediastinum was displaced to a greater or less degree.

4. The average age of the patients was 23 years, youth favoring a flexible mediastinum.

5. Pressures in the earlier reported cases were high (+ 8 + 14) but in the later cases never above + 1 or + 2.

6. Refills (when reported) were large, between 500 and 1,000 cc. at intervals of from ten days to two weeks.

7. An effusion was present in thirteen cases.

Fig. 6.—Large hernia of anterior part of mediastinum in a case of spontaneous pneumothorax complicating artificial pneumothorax. The position of the heart and the bronchus behind the hernia should be noted.

8. Dyspnea was the chief symptom produced by the hernia. A few complained of slight pains in the region of the hernia. In the four cases in which the hernia bulged in front of the heart and an effusion was present, there was marked cardiac and respiratory distress, followed by death in one instance.

9. In the cases so reported, when the hernia was once "reduced," it did not reappear again, and the symptoms were ameliorated.

Fluoroscopically, the view of a mediastinal hernia is startling, for one sees a high light with a dark, curving border expand and contract, as it were, with each respiratory excursion; on deep inspiration, it merges with the dense shadows of the mediastinum, and on expiration it protrudes into the sound side. During the expiratory phase, the mediastinum also swings to the healthy side with elevation of the diaphragm. The hernia may be seen more clearly if the patient is rotated slightly, so that an oblique view of it may be obtained. If the patient is examined fluoroscopically from the back, the hernia assumes larger proportions on the screen because of its location in the anterior part of the mediastinum. It is thus brought closer to the roentgen-ray tube.

The roentgenogram reveals the high light with a curved border in front of the trachea and heart shadows. The exaggerated appearance of the hernia when taken in the posterior view must be kept in mind, for it may be misinterpreted as a hernia of the posterior mediastinum.

No doubt many small mediastinal hernias are missed in the roentgenogram because, as a rule, chest exposures are taken at full inspiration, at which moment these hernias are reduced to their minimum size. To obtain the best roentgenogram of a hernia, the exposure should be made at deep expiration.

A mediastinal hernia may be mistaken for an intrapulmonary cavity.

Nitsch [5] showed that there are two "weak spots" in the mediastinum. The first or upper lies between the first and third ribs as the site of the atrophied thymus. By creating a pneumothorax in the cadaver on one side of the chest, he could produce a hernia at this spot. The second, or lower, weak spot lies posteriorly between the fifth and the tenth dorsal spines. Sauerbrach has pointed out the rarity of hernias at this place, and that when they do occur they are from right to left. Nitsch has shown schematically that a hernia at this site may bulge from right to left between the aorta and the esophagus, but that when pressure is brought to bear on these structures from the left pleural cavity, the esophagus overlaps the aorta and thus makes an effectual barrier.

COMMENT

A large pneumothorax is a factor found in all patients who have a mediastinal hernia. The mediastinum is displaced, and the diaphragmatic leaf is low. The pneumothorax assumes large proportions because the nonrigid mediastinum offers little resistance to the introduction of excessive amounts of air. The intrapleural pressures may always be negative. It is this displacement of the mediastinum that seems to "uncover" its weak spot, permitting the pneumothorax to push through at an advantageous moment. The act of coughing or straining is prob-

5. Nitsch: Beitr. z. Klin. d. Tuberk. **18**:1, 1911.

ably sufficient to break the medaistinal barrier, and a hernia results. I doubt if a hernia could be produced in the presence of a small pneumothorax.

Why the hernia expands and contracts may be explained as follows: If the chest wall and diaphragm undergo reasonably full respiratory excursions and if the collapsed lung varies but little in volume, then something must "give" for the reason that the volume of the pneumothorax is constant and is not subject to variations through passage of air by way of the trachea. Therefore, during expiration the mediastinum moves over as the diaphragm rises, and the chest wall falls in and the hernia bulges into the sound side. On inspiration, the reverse takes place, and the hernia is sucked back as the diaphragm sinks and the chest wall opens.

Graham and Bell,[6] in their experiments on the dog, showed that when an opening was made through the chest wall which permitted less air to enter the pleural cavity during inspiration than entered the lungs by way of the trachea, the animal was able to compensate for the loss of lung volume produced by the pneumothorax by deeper respiratory excursions, and the lung on the affected side was seen to expand and contract. When, however, a large opening was made, during the few minutes the animal remained alive, the mediastinum was seen to flap from side to side with each inspiratory and expiratory movement, and it sometimes happened that with a severe expiratory effort the anterior part of the mediastinum was ruptured so that a double pneumothorax occurred. In patients with a mediastinal hernia, a somewhat analogous condition is present. The pneumothorax, of course, is a closed one, but the air volume within the pleural cavity is large, and the patients by their dyspnea show a failure to compensate fully for loss of lung volume; in three instances reported in the literature, there was a rupture of the mediastinum and the production of a double pneumothorax.

The factors causing a mediastinal hernia are, fortunately, not frequently found in perfect combination. In the majority of patients undergoing therapeutic collapse, the mediastinum is rigid; or the lung is adherent at various places; or the diaphragm and chest wall on the pneumothorax side are practically immobile, or, if movement does take place, it is compensated for by variations in the volume of the collapsed lung during respiration.

Of what clinical significance are these hernias? The majority of patients exhibiting a small or medium sized hernia complain only of slight chest pains and moderate shortness of breath. As mentioned in the foregoing, the large hernias may cause distressing symptoms or even death.

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6. Graham, E. A., and Bell, R. D.: Am. J. M. Sc. **156**:839 (Dec.) 1918.

The danger of rupture of a mediastinal hernia is illustrated by the following case reported by Walsh:[7]

A man, aged 22, had had a right-sided collapse, beginning May 11. From then until July 14, he received 6,300 cc. of air, or an average of 500 cc. every five days. One month later he died. The clinical diagnosis at death was right-sided artificial pneumothorax and hydrothorax, and left-sided spontaneous pneumothorax. Before the chest was opened, the manometer showed a pressure of + 2 on the right side and + 8 on the left. Necropsy revealed 900 cc. of serous effusion in the right pleural cavity; the liver border below the umbilicus, and the diaphragm at the sixth rib on the right and the seventh rib on the left. The heart was displaced to the left. There was a pneumothorax on the left side. The right lung was compressed to about one-fourth its normal size. He stated that the right parietal pleura was distended over the left lung to the anterior axillary line to a point just above the horizontal mammary line, gradually receding above and below. He gave the cause of death as artificial pneumothorax on the right, which, extending across the mediastinum at the second rib into the left chest, ruptured into the left pleural cavity and produced a left pneumothorax.

The factors that I mentioned as necessary for the production of a hernia are here illustrated: an enormous artificial pneumothorax in which is found 900 cc. of fluid, a mobile mediastinum, a weak spot between the first and third ribs and a completely collapsed nonexpansile lung.

LeWald and Jones have each reported bilateral pneumothorax produced by rupture through the anterior mediastinum.

A mediastinal hernia shows that the pleura, in common with other serous membranes, is capable of great stretching.

For the pneumothorax operator the discovery of a mediastinal hernia must indicate but one thing—the pneumothorax is too large. The refills must be made smaller in amount and spaced farther apart. In this way the hernia is reduced and the mediastinum is allowed to swing back to a more normal position. Once the hernia is reduced, it does not tend to recur, and the artificial pneumothorax treatments may be continued with safety.

CONCLUSIONS

A mobile mediastinum and a large pneumothorax seem to make the "weak spot" in the upper anterior part of the mediastinum more vulnerable to the pushing through of a hernia.

These hernias may be present when the pressure within the pneumothorax cavity is negative.

Large mediastinal hernias, or a rupture of the hernia, endanger life.

Reduction of the volume of the pneumothorax causes the hernia to disappear.

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7. Walsh, J.: Am. Rev. Tuberc. 9:337 (June) 1924.

EVENTRATION OF THE DIAPHRAGM

DIAGNOSIS AND TREATMENT, WITH A REPORT OF FOUR CASES

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Eventration of the diaphragm is a rare anomaly of obscure origin characterized by the permanent high position of one leaflet of the diaphragm and the displacement into the thorax of the abdominal viscera on the affected side.

Bamberger [1] in 1913 compiled thirty-one cases. Bayne-Jones [2] gathered forty-four from the literature and added one of his own. Korns [3] critically reviewed the reported cases and regarded twenty-two as proved and forty-three as probable, giving a total of sixty-five certain or probable cases to 1921. A number of cases have since been reported. Four have come under observation at the Massachusetts General Hospital in the course of 16,504 roentgen-ray examinations of the chest.

IMPORTANCE OF EVENTRATION

The number of patients with eventration of the diaphragm likely to come under the observation of any one person is small. Recognition of the existence of such a group of cases is important, however, to prevent confusion with other intrathoracic conditions. Without the assistance of the roentgen ray, eventration of the diaphragm has been mistaken for pleural effusion, and exploratory thoracentesis and thoracotomy have been performed. The anomaly is chiefly of importance, however, on account of the readiness with which it may be confused with diaphragmatic hernia, and differentiation between these two conditions may be impossible even after resort to all available safe methods of investigation, short of exploratory laparotomy.

Eventration of the diaphragm is important also from an entirely different point of view. Within the last few years there has been an increasing tendency to resort to phrenicotomy in the treatment of pulmonary tuberculosis, for the purpose of supplementing the usual hygienic-dietetic regimen or as a preliminary to a more radical surgical procedure. Unilateral phrenic paralysis produced by the surgeon displaces thoracic and abdominal organs as in the anomaly with which we

1. Bamberger: Ergebn. d. inn. Med. u. Kinderh. **12**:327, 1913.
2. Bayne-Jones, S.: Eventration, Arch. Int. Med. **17**:221 (Feb.) 1916.
3. Korns, H. M.: Diagnosis of "Eventration" of Diaphragm, Arch. Int. Med. **28**:192 (Aug.) 1921.

are here concerned. It should be appreciated that a majority of the patients with eventration suffer from more or less troublesome symptoms, which may be ascribed to the displacement of important viscera, and before we proceed much further in the resort to phrenicotomy it would seem desirable to determine whether equally troublesome symptoms are also to be expected in this group to be operated on.

The first two cases are noteworthy because of the severity of the symptoms.

Fig. 1 (case 1).—Chest, showing the dome of the left side of the diaphragm opposite the anterior portion of the third rib; the heart and mediastinal contents are displaced to the right.

REPORT OF CASES

Case 1.—X. Y. Z., a physician, aged 45, who was examined Aug. 25, 1922, had been less capable than others of physical exertion all his life, but from a sense of exhaustion rather than from dyspnea. For the last six years he had been short of breath. A malposition of the left side of the diaphragm had been discovered by fluoroscopy twenty years before examination. At that time after sneezing he had had violent pain in the left side of the neck lasting for six weeks. During this period he had been troubled by pain on swallowing and laryngeal spasm which made it difficult to breathe. For the following sixteen years he had had from one to four similar attacks each year, lasting from one to two months. He then had discovered that he could stop these attacks by staying in bed. During the last four years, he had had twelve attacks of agonizing pain

in the middle of the right side of the chest in front, lasting from fifteen to thirty minutes. The pain radiated to the upper part of the right side of the chest and forearm. It came without warning, usually in the late morning, was unrelated to exertion and was increased by a long breath. He was short of breath during these attacks. In addition, for the last four years he had had a constant dull, aching pain across the front of the chest, aggravated by taking a long breath and relieved by lying down. During the more severe attacks of pain, he had a dry cough, which subsided after a few hours rest in bed. Ordinarily there were no gastro-intestinal symptoms, but during periods of more severe thoracic pain he was unable to eat on account of distress in the left hypochondrium. He felt this about half an hour after eating, and it lasted for from one to two hours. Ten years before examination, for a period of three days he had had abdominal pain, distention, nausea and vomiting, with no bowel movement during this time. There had been no fecal vomiting. He was much incapacitated for work and spent an average of perhaps from ten to twelve days in bed each month.

The patient was well developed and nourished. The chest was symmetrical, and expansion of the two sides was equal. The left side was dull in front below the fifth rib, and behind from a short distance below the angle of the scapula to the base. There was no tympany. The breathing was much diminished, without bronchial quality, voice sounds were diminished and without egophonic quality, and the tactile fremitus was absent over the dull area. There was no succussion splash.

Roentgen-ray examination showed the dome of the left side of the diaphragm of unbroken contour opposite the anterior portion of the third rib. With forced inspiration there was slight reversed excursion. The right side of the diaphragm was normal. The heart and mediastinal contents were displaced toward the right. Barium was seen to pass through the esophagus in the usual manner, and showed the stomach lying below the diaphragm.

The sudden onset of symptoms after sneezing twenty years before and their character in the succeeding years suggested diaphragmatic hernia rather than eventration. The roentgen-ray report, however, was consistent with eventration.

CASE 2.—M. A. J., a married woman, aged 55, seen Aug. 23, 1926, for the last three years had been short of breath and unable to climb more than four stairs without dyspnea. She was unable to lie on the right side without dyspnea, but could lie comfortably on the back and left side. There had been slight wheezing with exertion and on lying down for two years. She had had a cough for three years, daily raising about one-half teaspoonful of white sputum without blood.

For three years there had been attacks of nonradiating, dull, aching pain to the right of the midline in the epigastrium, lasting from one to two minutes and recurring about once daily, usually at night on lying down. This pain had been severe enough to double her up and make her groan, but not to keep her awake. The appetite had been poor. Nausea had been troublesome at varying intervals for five months. There had been no vomiting and no distress after eating. The bowels moved daily. She was not especially troubled by gas.

For the last five months she had had "dizzy, sinking" spells once or twice a day, lasting for about half an hour. She slept poorly and passed urine from two to three times at night. The maximum weight was now 143 pounds (64.9 Kg.); her height was 5 feet, 3 inches.

The patient was well developed and slightly obese. There was slight cyanosis of the lips. The chest was symmetrical; the circumference of the left half was 41 cm., of the right half, 42 cm. With the patient on her back, the inspiratory excursion of the left side was greater than that of the right. This exaggerated motion was noticeable throughout the left side of the chest in front from the left clavicle to the costal margin. There was an exaggeration of the inspiratory widening of the left side of the subcostal angle and the left costal margin with inspiratory retraction of the epigastrium. On percussion, the left side was dull

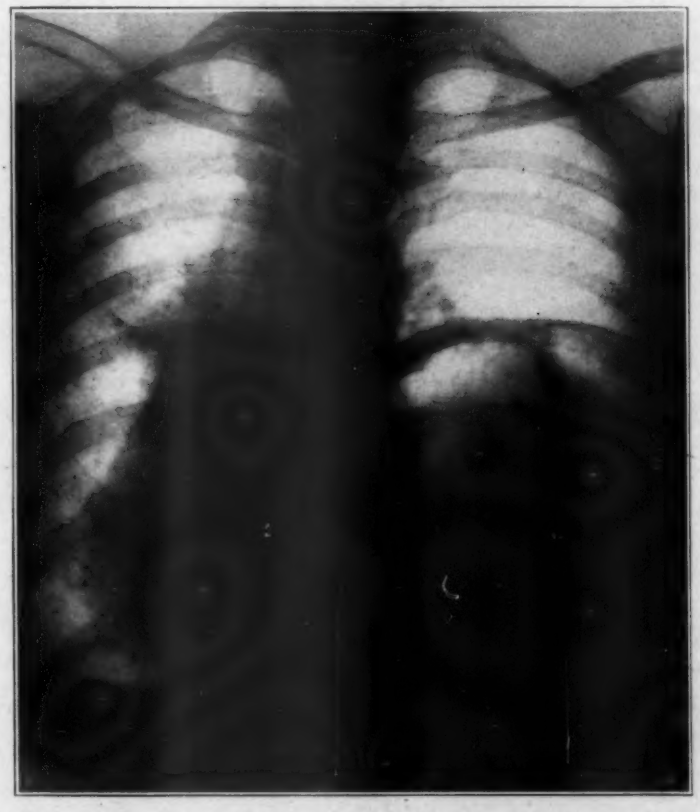

Fig. 2 (case 2).—Chest, showing the dome of the left side of the diaphragm opposite the anterior portion of the third rib; the heart and the mediastinal shadow are displaced to the right.

below the third rib in front and the middle third of the scapula behind. The note was dull and tympanitic over and below the left breast. There was no tympany in the left axilla or back. The upper border of dulness behind was highest in the region of the scapula, and curved slightly downward from this point toward the spine and the axillary region. The left paravertebral region was less dull than other parts of the left side of the back. There was no Grocco's triangle of dulness and no spinal dulness. The inspiratory excursion by percussion was 3 cm. in the right and 1 cm. in the left side of the back. The diaphragm shadow (Litten's phenomenon) was absent on both sides.

On auscultation the breath sounds were much diminished (not bronchial) over the upper half and absent over the lower half of all parts of the dull area in the left side of the chest. Gurgling sounds resembling those due to intestinal peristalsis were heard below the left third rib in front and the midscapula behind. No râles were heard. The voice sounds were diminished over the upper and absent over the lower half of the dull area. No egophony was heard, no whisper throughout, and no succussion splash. Tactile fremitus was absent throughout the dull area.

The cardiac impulse was not seen or felt. The heart sounds were regular and of good quality. No murmurs were heard. The cardiac sounds were louder to the right than to the left of the sternum. By percussion the right border of the heart was one finger breadth inside the right nipple line.

Examination of the right lung was negative throughout.

Roentgen-ray examination showed the dome of the diaphragm to be on the left side opposite the third rib in front. Its outline was smooth. Respiratory motion was normal, but somewhat limited in amplitude. The heart and mediastinal shadow were displaced to the right. There were no movements of the mediastinum with respiration. Below the diaphragm shadow the gas filled fundus of the stomach was seen, after the administration of barium by mouth. External to this was the shadow of the colon, identified by barium enema. There was no evidence of dilatation of the colon. The splenic flexure was seen lying along the greater curvature of the stomach and in contact with the elevated diaphragm. The lumen of the bowel was normal throughout.

The symptoms and the results of physical and roentgen-ray examinations were consistent with eventration of the diaphragm. The exaggerated inspiratory excursion of the left side and the exaggerated inspiratory divergence of the left costal margin were noteworthy and of probable diagnostic significance.

In the two following cases the symptoms were insignificant:

CASE 3.—F. D., a barber, aged 33, married, who was seen Aug. 30, 1926, had visited the Massachusetts General Hospital at intervals during the three years ending three years before. He had complained of fatigue and a sense of "weakness in the left side of the back," gastric flatus, rumbling noises in the left side of the upper part of the abdomen and in the left side of the lower part of the chest in front, constipation and vague pains in the left upper quadrant of the abdomen, associated with gas and relieved by belching and passage of gas by rectum and by defecation. Fatigue at his work as an edge trimmer in a shoe factory appears to have been a factor in his symptoms, which would disappear when he stopped work. There had been no other significant symptoms and no complaints for the last three years. There had been no dyspnea, cough, wheezing or pain in the chest.

On examination the patient was found to be well developed and well nourished. The chest was symmetrical. The circumference of the left half of the chest was 39 cm.; of the right, 38.5 cm. With the patient on his back, the inspiratory expansion of the two sides of the chest as a whole was the same, but there was an exaggerated divergence of the left costal margin from the median line in the epigastrium with consequent greater widening of the left than of the right side of the subcostal angle. There was inspiratory retraction of the epigastrium. On percussion, the left side of the front of the chest was dull below the second rib and the left side of the back was dull below the spine of the scapula. The

note was dull and tympanitic throughout the left front of the chest and axilla as far as the postaxillary line. Posteriorly, the upper limit of dulness was over the scapula and curved thence downward toward the spine and postero-axillary region. The left paravertebral region was less dull than other parts of the left side of the back. There was no Grocco's triangle and no spinal dulness. The inspiratory excursion was 3 cm. on the right and 1 cm. on the left. The diaphragm shadow was 3 cm. in amplitude in the right axilla and was not seen on the left side. On auscultation, the breath sounds were present but diminished throughout the left side. No bronchial breathing was heard. Gurgling sounds

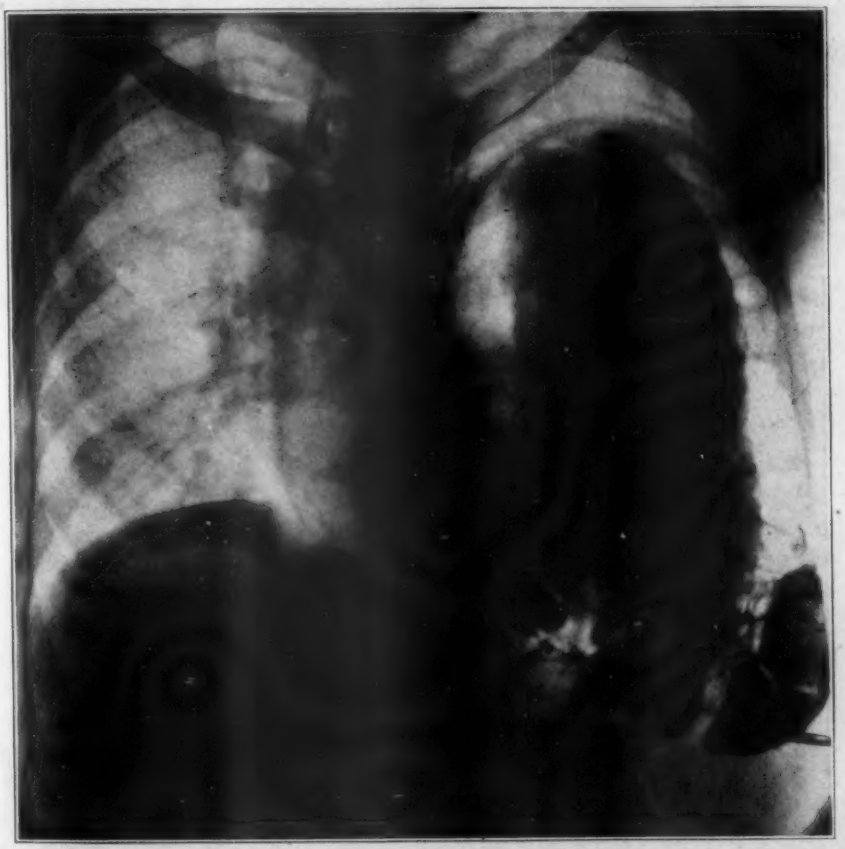

Fig. 3 (case 3).—Chest, showing the dome of the left side of the diaphragm opposite the anterior portion of the first rib.

resembling those due to intestinal peristalsis were heard below the left clavicle, throughout the left axilla and as high as the spine of the left scapula behind. The voice and whisper were normal throughout the left side. No egophony, succussion splash or râles were heard. Tactile fremitus was diminished but not absent throughout the left side below the second rib in front and the spine of the scapula behind.

The cardiac impulse was felt in the fifth left interspace at the nipple line. The heart sounds were regular and of good quality. No murmurs were heard. The rate was 72.

Examination of the right lung was negative throughout.

Roentgen-ray examination showed the dome of the diaphragm to be on the left side opposite the third rib during inspiration, and opposite the first rib during expiration. It moved somewhat less than the right, but in a normal manner. Below it the outline of the gas filled fundus of the stomach and the colon could be seen. The heart and mediastinal shadow moved toward the left with forced inspiration and toward the right with expiration. Examination of the gastro-intestinal tract was made with barium administered by mouth and by enema.

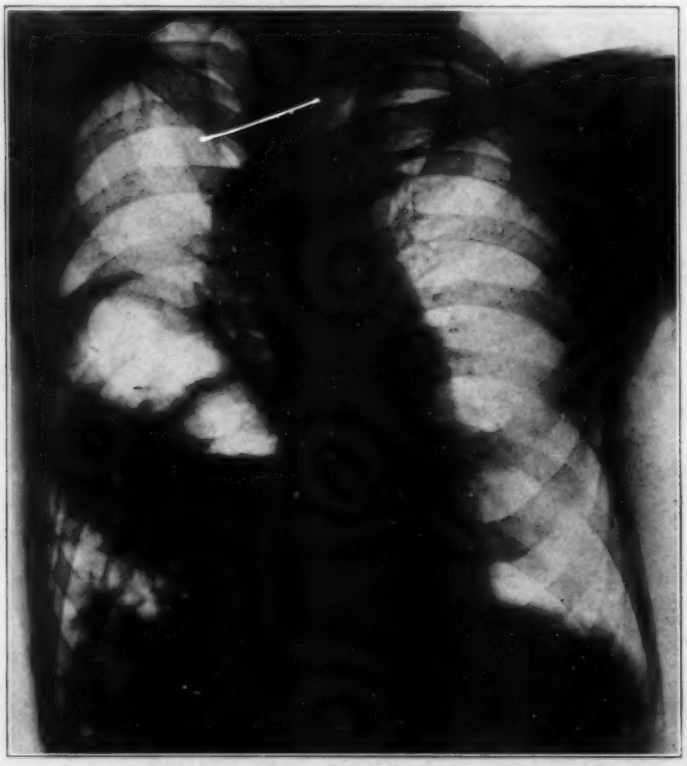

Fig. 4 (case 4).—Chest, showing the dome of the left side of the diaphragm opposite the anterior portion of the third rib.

There was no evidence of dilatation of the colon; it was malposed, however, the sigmoid lying in the right iliac fossa and the cecum well to the left of the median line and unusually high.

Case 4.—J. H. O., a man, aged 66, married, without occupation, nine years before he was seen, April 22, 1926, had had a "shock," and he had been unable to talk since. He had entered the Massachusetts General Hospital, April 10, 1926, for an inoperable carcinoma of the lip, and had been discharged, April 22, 1926. There were no symptoms referable to the chest or abdomen. Examination showed dulness on the left side below the third rib in front and the angle of the scapula behind. There was dull tympany over the left front of the chest below the third rib. The breath sounds were diminished but not bronchial over the dull area. No

succussion splash was heard. The voice sounds were normal, and there was no egophony. Abnormally loud, gurgling sounds due to intestinal peristalsis were heard as far upward on the left as the highest part of the axila. Tactile fremitus was absent over the dull area. Roentgen-ray examination showed the dome of the diaphragm to be on the left side opposite the third rib in front and the sixth rib behind. The heart shadow appeared somewhat displaced to the right, but its position was somewhat obscured by scoliosis of the spine.

The physical and roentgen-ray observations in the last two cases were consistent with eventration of the diaphragm. No observation on the respiratory movements of the chest was made in case 4. Unlike the observations in case 2, the inspiratory excursions of the two sides of the chest in case 3 were as a whole the same. An exaggerated outward inspiratory motion of the left costal margin was observed in case 3 as in case 2.

DIAGNOSIS

There are no distinctive symptoms of eventration. In some cases there are no symptoms. In others, there are such cardiopulmonary manifestations as dyspnea, orthopnea, wheezing, attacks like asthma, cough with or without expectoration and pain in the left side of the chest. In still other cases, there are gastro-intestinal disturbances, distress, fulness or pain after eating, nausea, vomiting and constipation. A kink in the lower part of the esophagus as in Otten and Schefold's [4] case may cause difficulty in swallowing. In a fourth group, cardiopulmonary and gastro-intestinal symptoms may be combined.

On physical examination, the heart is likely to be found displaced to the opposite side, usually the right. On inspection, the chest is usually symmetrical. The diaphragm shadow (Litten's phenomenon) is absent on the affected side. The excursion of the two sides of the chest was reported by Korns [3] to be equal in eight, with slight lagging in two, absent motion in one and better movement on the affected side in one.

The observations of Hoover [5] on the functions of the diaphragm suggest that in the presence of eventration important evidence may be obtained by comparison of the respiratory movement of the two sides of the chest. His clinical and experimental observations indicate that the diaphragm acts as an antagonist to the intercostal muscles, which enlarge the transverse and anteroposterior diameter of the base of the thorax and widen the subcostal angle. The extent to which the diaphragm is capable of opposing the intercostal muscles depends on its arch, and the more nearly the curve approaches a plane the greater its mechanical advantage. If the diaphragm is at a mechanical disadvantage

4. Otten and Schefold: Deutsches Arch. f. klin. Med. **99,** 1910.

5. Hoover, C. F.: Tr. A. Am. Phys. **28,** 1913; Functions of Intercostal Muscles, J. A. M. A. **73**:17 (July 5) 1919; Am. J. M. Sc. **159**:633 (May) 1920.

by upward displacement or if its musculature is impaired, the pull of the intercostal muscles is accentuated.

There are few cases in the literature in which sufficient attention has been paid to respiratory motion in the presence of eventration of the diaphragm to test the diagnostic value of Hoover's observations. The reports by Funk,[6] Korns [3] and Reifenstein,[7] however, support Hoover's contention and indicate that important evidence may be obtained by simple inspection of the chest. In a case with eventration of the left side of the diaphragm, Funk found distinct inspiratory widening of the subcostal angle due principally to a greater divergence of the left costal border. Korns, in a case of right-sided eventration, noted marked diminution in the undulatory movement of the right upper five ribs and distinct impairment in the excursion of the arches of the lower seven ribs; with the patient recumbent, there was an inspiratory divergence from the median line of the entire right costal margin from the xiphoid to the posterior axillary line in excess of that on the left side. . In Reifenstein's case, with left-sided eventration the upper and lower costal margins on the left side moved outward more than on the right. As already noted in the report of the cases I have seen, the respiratory movements in two (cases 2 and 3) were similar to those to be expected from Hoover's observations and like those seen in the cases reported by the authors just mentioned. In the other two cases, no observations were made on this matter. From the evidence presented by these five cases, Hoover's signs would seem to be of importance in the diagnosis of eventration of the diaphragm.

Hoover [8] attributes even greater importance to the signs just mentioned than these cases would indicate. In comment on Funk's [6] article, he stated that the observation of increased movement of the costal margin on the affected side would be of service in the differentiation between hernia and eventration, and that in hernia the movement of the costal margin was not modified. This difference in the behavior of the diaphragm in the presence of hernia is explained by Korns [3] on the ground that in this condition the diaphragm is not aplastic and in a high position, but has intact muscles and an approximately normal position. From the physical signs Hoover was able to make the diagnosis of hernia of the left side of the diaphragm in Korns' second case, in which by fluoroscopic examination the stomach was seen to lie almost entirely in the left pleural cavity.

These observations are of great importance in view of the difficulty of distinguishing between diaphragmatic eventration and hernia by

6. Funk and Manges: M. Rec. **98**:289, 1920.
7. Reifenstein, E. C.: Am. J. M. Sc. **169**:668 (May) 1925.
8. Hoover, C. F.: Tr. A. Am. Phys., 1920, vol. 35.

clinical means alone, and it is desirable that their value be further tested in cases that subsequently come to operation or necropsy, as by such means alone can the diagnosis be established beyond doubt.

Other physical signs, dulness, dull tympany, diminished or absent breathing, diminished or absent voice, whisper and tactile fremitus, are found with a variety of intrathoracic conditions (pulmonary cysts, tumors, atelectatic areas from bronchostenosis and accumulation of fluid or solid material in the pleural sac), as well as with diaphragmatic eventration and hernia. When in addition to such signs it is noted that the dulness changes with the intake of food or fluid into the stomach, eventration or hernia may be suspected. The presence of sounds due to intestinal peristalsis over the affected side has been noted in a number of the reported cases. When such sounds are abnormal in their loudness or extent, they may have diagnostic significance and serve to suggest diaphragmatic eventration or hernia; but in the interpretation of peristaltic sounds over the thorax as an indication of eventration of the diaphragm or hernia, it must be remembered that such sounds are normally present over the lower parts of the chest, and may be heard on the left as high as the third rib in front and the lower third of the scapula behind, and at a somewhat lower level on the right. They are much louder on the left than on the right side. I have compared the intensity and extent of these sounds in the three cases reported here with similar sounds in normal chests, and doubt that they have any special diagnostic value.

Of special methods of examination, determination of changes in intragastric pressure with other evidence enabled Hildebrand and Hess [9] to make the differential diagnosis between eventration and hernia in the much discussed case of Schneider, who was examined in many German clinics from the age of 12 until his death at 46. A stomach tube was connected with a manometer, the lever of which indicated on a revolving drum the changes in intragastric pressure. A tracing of the respiratory movements was taken at the same time. The curves with deep breathing were identical with those obtained [10] from a normally placed stomach, i. e., a fall of pressure at the beginning both of inspiration and of expiration and a subsequent increase in pressure to the height of both phases of respiration. They concluded that if the stomach showed normal pressure curves, especially a positive pressure at the height of inspiration, it must lie under the diaphragm. At necropsy [11] their diagnosis of left-sided eventration of the diaphragm was confirmed.

This method, of value in this case, deserves further trial. It was not used in the cases reported here. There is one other report of its use

9. Hildebrand and Hess: München. med. Wchnschr. **16,** 1905.
10. Schlippe: Deutsches Arch. f. klin. Med. **76,** 1903.
11. Bergmann: Ergebn. d. inn. Med. u. Kinderh. **12:**327, 1913.

in the literature, and this indicates that one might easily be led astray in the interpretation of the curves. Minkowski,[12] in a case of eventration of the diaphragm, found on manometric determination of the intragastric pressure an inspiratory fall with costal breathing and an inspiratory rise of pressure with abdominal breathing. Observations of the respiratory pressure relations in the stomach herniated through the diaphragm are needed to determine the truth of the assumption that they are the reverse of those found in the normally placed stomach before the merits of this procedure can be estimated.

Roentgen-ray examination is practically always necessary to establish the diagnosis of eventration of the diaphragm or of diaphragmatic hernia. It is indispensible also, but cannot always be relied on, in the differentiation between eventration and hernia.

In the presence of eventration, roentgen-ray examination shows the high position on one side of an unbroken arched line resembling the dome of an elevated diaphragm, and below it toward the median line a shadow resembling that of the gas-filled fundus of the stomach. External to this are shadows consistent with those due to the colon. The identity of the stomach and colon may readily be established by roentgen-ray examination after administration of barium by mouth and a barium enema. The heart and mediastinal shadow are likely to be displaced to the opposite side, usually the right side.

A difficulty in the roentgen-ray examination is the identification of the arched line as the shadow of the elevated diaphragm. That it cannot always be so regarded is indicated by the observations in Lotze's [13] case, in which on the left side a sharply arched line was seen reaching upward to the third rib. Lotze's clinical diagnosis of relaxation of the diaphragm was disproved at necropsy, which showed a diaphragmatic hernia and the stomach, a large part of the transverse colon and the great omentum in the left pleural cavity. Although an unbroken arched line is essential for the diagnosis of eventration, it cannot be regarded as a distinctive sign of this condition.

The relation of the affected diaphragm to respiratory motion, immobility, normal or paradoxic movement has no diagnostic value in the differentiation of eventration from hernia. Respiratory excursion of the mediastinum was absent in case 2 reported here. In case 3, there was movement toward the affected side with inspiration and toward the opposite side with expiration. Otten and Schefold [4] made a similar observation in their case. Korns [3] rejects this case from the category of eventration on the ground that the observation implies a greater negative intrapleural pressure on the left than on the right side, and he cannot

12. Minkowski: Berl. klin. Wchnschr. **54**, 1917.
13. Lotze: Deutsche med. Wchnschr. **40**, 1906.

conceive of this with the left half of the diaphragm the seat of aplasia. Defective development of the diaphragm has been established at necropsy in certain cases but is not necessarily implied by the term eventration, and in the case reported by Duval and Quenu,[14] the diaphragm at operation had a normal appearance and thickness. Owing to the much phragm had a normal appearance and thickness. Owing to the much smaller volume of that part of the thoracic cavity above the affected diaphragm compared with that of the opposite side, a relatively greater negative pressure may result from the descent of the diaphragm and contraction of the intercostal muscles on the affected side. In consequence of such relatively greater negative pressure on the affected side, the heart and mediastinum, if free from adhesions, may be expected to move toward that side, and the observation does not seem inconsistent with mechanical conditions which may obtain with eventration of the diaphragm.

Roentgen-ray examination after the production of pneunoperitoneum may be regarded as the most certain means of differentiating eventration from diaphragmatic hernia. It is a question, however, whether its dangers justify its use. Schlecht and Wels [15] were deterred in a doubtful case of eventration of the diaphragm from the employment of this method on account of the possible dangers until the diagnosis had been established by exploratory operation. Roentgen-ray examination then enabled them to identify the arched line above the oxygen filled abdominal cavity as that of the diaphragm. After the abdomen had been insufflated with 1,500 cc. of oxygen, the patient complained of pain, which was ascribed to the stretching of adhesions between the liver and the diaphragm. In the presence of diaphragmatic hernia, pneumoperitoneum may entail some risk. The absence of a sac in a large majority of the cases of diaphragmatic hernia makes it likely that the introduction of gas into the peritoneal cavity will cause pneumothorax, on account of imperfect closure of the defect in the diaphragm by the hernia. Schlecht and Wels [16] report the use of this method also in a case of congenital diaphragmatic hernia, and were thus able without difficulty to recognize the nature of the disturbance. The production of pneumothorax by the introduction of the gas into the abdomen indicated the presence of an open communication between the abdomen and the thorax. The spleen, stomach and other shadows due to the stomach or large intestine were seen above the diaphragm. Three weeks after entrance to the clinic, the patient had a severe attack of pain, and was in a condi-

14. Duval and Quenu: Bull. et mém. Soc. nat. de chir. **50**:178, 1924.

15. Schlecht and Wels: Fortschr. a. d. Geb. d. Röntgenstrahlen. **27**:244, 1920.

16. Schlecht and Wels: Fortschr. a. d. Geb. d. Röntgenstrahlen. **27**:544, 1920.

tion resembling collapse. Immediate operation showed a perforation of the stomach with gangrene of the adjacent parts of the greater curvature. The possibility could not be excluded that interference with the blood supply of the stomach by its displacement in consequence of the pneumoperitoneum might have been responsible.

The question of the use of pneumoperitoneum as a differential diagnostic measure is likely to arise in a small group of cases in which the symptoms are more suggestive of hernia than of eventration, and are sufficiently severe to warrant a consideration of surgical intervention for relief. In view of the risks entailed by the production of pneumoperitoneum in such cases, an exploratory laparotomy would seem a safer procedure, and if by this means a diaphragmatic hernia is found, its repair, if feasible, may at the same time be attempted.

In cases in which hernia of the diaphragm can be excluded and the diagnosis of eventration established, fluoroscopic observation of the respiratory movements may afford evidence of value in determining the nature of the underlying disturbance. In the cases reported by Felix,[17] after phrenicotomy and exeresis the movements of the affected side of the diaphragm when present were constantly paradoxic. Its motion under these circumstances is entirely passive, and elevation during inspiration is due to increased intra-abdominal pressure in consequence of the descent of the unaffected half of the diaphragm. In view of these observations it may be suggested that when the respiratory motion of the eventrated diaphragm is paradoxic phrenic nerve paralysis as a cause may be suspected. Normal respiratory motion of the eventrated diaphragm implies an uninterrupted nerve supply and suggests a developmental defect in the muscular tissue as a cause of the anomaly. Correlation between the fluoroscopic observations during life and postmortem observations are desirable before any definite conclusions regarding this matter can be made.

TREATMENT

Therapeutic measures will usually be limited to advice to avoid strenuous exertion, to lose weight if the patient is overweight for age and height, and other recommendations suited to the individual case. Operative procedures are not ordinarily indicated, but in cases in which the symptoms are troublesome or intolerable, surgical intervention may be considered. In Lerche's [18] case, with eventration and an esophagotracheal fistula there was cough, dyspnea, inability to lie on the back or the right side without pain, and epigastric pain, distress and vomiting. Two plaits were taken in the diaphragm through an incision in the outer part of the left rectus muscle, with the addition of a cross incision in the

17. Felix, W.: Deutsche Ztschr. f. Chir. **171**:283, 1922.
18. Lerche, W.: Surg. Gynec. Obst. **34**:224 (Feb.) 1922.

upper end of the rectus muscle. Seven months later there were "hardly any cough," no digestive symptoms and ability to lie on the back and right side with perfect comfort. In Duval and Quenu's [14] case, surgery was advised on account of almost daily paroxysms of severe pain in the left hypochondrium, and was preceded by the production of artificial pneumothorax to avoid the danger of sudden collapse of the lung during operation. A thoraco-abdominal incision was made, and three plaits were taken in the diaphragm. For two months after operation there were no paroxysms resembling those the patient had had before.

I am indebted to Dr. George W. Holmes for his cooperation and assistance in the roentgen-ray examination of these patients.

ABSTRACT OF DISCUSSION ON PAPERS OF DRS. PACKARD AND LORD

Dr. J. J. Singer, St. Louis: This question of the use of pneumothorax and its availability to surgeons is resulting in the latter attaching internists to their staffs, so that what occurs in pneumothorax cases is of vital importance to internists, especially this particular point, hernia of the mediastinum. I have been somewhat in doubt as to whether it is really a hernia, whether the mediastinum is actually torn through and the pleura extends into the opposite cavity, or whether the mediastinum, as a whole, is pushed into the opposite lung space. One of the greatest surprises to surgeons performing pneumothorax is the observation through the fluoroscope of a tremendous air pocket when 200 or 300 cc. of air is forced into the pleural space. How did it get there? Evidently there was spontaneous rupture of the lung during the performance of artificial pneumothorax. That happens much oftener than is suspected. Frequently, the spontaneous rupture or the amount of air that enters the pleural cavity is small because of adhesions of the pleura at various parts, so that it is always best to look with a fluoroscope. One should not stop with the manometer readings. Manometer readings are misleading. A negative pressure may be recorded and yet the pleural space be full of air. That is because the collapsed lung is so much collapsed that it is almost theoretically a part of the mediastinum tissue; hence, the opposite pleural pressure is being registered. Graham and Bell's work showed that when pressure is taken that way, the pressure of the opposite cavity is being taken. I feel that a pneumothorax performed in the home or without the use of the fluoroscope is a mistake.

Dr. Carl A. Hedblom, Chicago: Dr. Lord has raised an interesting question in relation to phrenicotomy. His observations show the importance of being conservative in recommending this operation, which in itself is so simple and seemingly harmless that we may be tempted to use it in cases in which it is not properly indicated. On the other hand, I think that the question as to indications for it is one of relative value. In the treatment of tuberculosis, it must not be forgotten that one is dealing with a serious disease which if not arrested will eventually cost the patient his life. And an operation that may prove helpful in securing arrest of the tuberculous process would seem justified even at the expense of a certain amount of functional derangement. In case phrenicotomy is preceded or followed by thoracoplasty, it would also seem probable that the collapsed state of the lower thorax might well tend to counteract any tendency to functional derangement from a high nonfunctioning diaphragm. I have also

observed cases of diaphragmatic hernia of extreme grade, and cases of absence of one leaf of the diaphragm. I have also found many similar cases, without symptoms, reported in the literature, almost so that I think it is necessary to consider carefully just what the relation is between eventration of the diaphragm and the symptoms of which the patient complains in a small series of cases.

Dr. John L. Yates, Milwaukee: I have observed the effects of induced palsy of the diaphragm over a period of approximately two years in more than a hundred patients. Temporary paralysis was induced by crushing the phrenic nerve and such of the accessory branches as transmitted motor impulses in eighty-five patients. It is impossible to study the effects of this paralysis on the patient before and after reactivation of the diaphragm. Eighteen radical operations were performed in which the nerve was extracted or resected when extraction was unwise. In none of these patients did there develop a manifestation of any intra-abdominal functional disturbance that could be attributable to the paralysis. Those who recovered function of the diaphragm so far as we could tell, did not show any particular difference before and after. Paralysis of the diaphragm reduces vital capacity, restricts external respiration and impairs competence. Dyspnea on exertion is inevitable. Blocking the phrenic nerve lessens intrathoracic distress. It is not likely that the untoward manifestations of the patients in the cases Dr. Lord reported were due to the eventration and not provoked by the high position of the diaphragm.

Dr. William Lerche, St. Paul: In a case of eventration of the diaphragm in which I operated some years ago, the dyspnea and the gastric symptoms were pronounced. The patient was relieved after I plicated the diaphragm. In some cases the eventration gives rise to severe symptoms; in others there are no symptoms. The question suggested by Dr. Lord is a timely one: How do we know that such symptoms may not come on in cases in which eventration has been induced by the removal of part of the phrenic nerve?

Dr. Leo Eloesser, San Francisco: There has been reason to suspect that some of these eventrations of the diaphragm are due to phrenic birth paralysis. Has Dr. Lord done a faradization of the phrenic nerves in the neck and watched the patients on the screen? This procedure may give evidence of muscular fibers or their absence on the one side of the diaphragm.

Dr. Willy Meyer, New York: The terms diaphragmatic hernia and diaphragmatic eventration are defined and understood; but here the term mediastinal hernia is used, a term accepted in the literature. Is it wise to call this bulging a hernia whereas, on the other hand, the speaker mentioned a rupture of the mediastinum to the other side? I think this nomenclature should be corrected. There is still time to do so. Modern thoracic surgery began from eighteen to twenty years ago. I would suggest a differentiation by calling it, for instance, mediastinal bulging toward the opposite side. It seems wrong to me to speak of a mediastinal hernia in these cases.

Dr. Edward S. Welles, Saranac Lake, N. Y.: I should like merely to add my experience to that of Dr. Yates in regard to phrenicotomy. I have performed forty-nine or fifty, and have had the same experience as he. So far I have had no evidence in any case of undue shortness of breath or any abdominal trouble after the operation. I agree entirely with Dr. Yates as to his observations.

Dr. Howard Lilienthal, New York: Let me corroborate what Dr. Willy Meyer has just said in regard to the so-called hernia of the mediastinum. It is not a true hernia but a displacement of part of the mediastinum. I would also call attention to the impropriety of the descriptive title, eventration of the diaphragm. "Venter" is the Latin for belly. That part of the cavity that is under-

neath the diaphragm is the belly. It is the elevation of the belly and not the eventration of the diaphragm. I suggested that it be called elevation of the diaphragm and not eventration. Another misnomer is worth mentioning. If you will refer to a recent number of the *Journal of the American Medical Association,* you will find a letter of mine on the use of the word "benign" in contradistinction to "malignant." There is no such thing as a benign tumor. It may be nonmalignant or innocent, but no tumor is benign.

Dr. Leon T. LeWald, New York: Dr. Lord asked for an opinion as to the value or use of artificial pneumoperitoneum in the differential diagnosis of lesions about the diaphragm. I am opposed to it, as not being necessary and somewhat dangerous. It is always possible to show the entire diaphragm roentgenographically if one makes a careful lateral exposure. One can show both sides of the diaphragm in a normal person. It is not necessary to inject air into the peritoneal cavity to make a differential diagnosis between eventration and diaphragmatic hernia, or congenital absence of the left side of the diaphragm.

Dr. Frederick T. Lord, Boston: Dr. Lilienthal's criticism regarding the term eventration is well made. The term is a misnomer. The only justification for it is common usage. Regarding the possible dangers to the patient of a phrenicotomy and exeresis, I do not believe that one can judge the matter so early in experience with this procedure. Persons with eventration apparently may go for a long period without symptoms and then develop symptoms, and the question as to the deleterious effect of this procedure cannot be answered without the lapse of more time. The suggestion was made that a determination of the nature of the disturbance may be made by electrical stimulation of the phrenic nerve. Lack of response might be taken to indicate a disturbance in the nerve. It might also be taken to indicate no response in muscle that is inefficient. I think there is some doubt as to the interpretation of the results, and there has been no experimentation with this procedure.

Dr. E. N. Packard, Saranac Lake, N. Y.: I think Dr. Lilienthal's criticism of the word "hernia" is justified but it is a term that has been used generally in the German and French literature to describe the culdesac, or pouch, which bulges into the sound side across the mediastinum. The "hernia" is covered by the parietal pleura of the pneumothorax and by the parietal and visceral pleura of the sound side.

CONGENITAL ABSENCE OF LEFT HALF OF THE DIAPHRAGM

DIFFERENTIAL DIAGNOSIS FROM EVENTRATION, HERNIA AND THORACIC STOMACH, WITH A REPORT OF THREE CASES

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The first case of congenital absence of the left half of the diaphragm, although reported by Harris and Clayton-Greene [1] in 1912, appears to have been overlooked since that time (figs. 1 and 2). Without doubt many cases recorded as hernia of the diaphragm have really been cases of congenital absence of the left half of the diaphragm. Even roentgenologists have not recognized the true nature of these cases. Surgical operations have been undertaken under an erroneous diagnosis of hernia, and attempts to overcome the defect have failed.

Attention is called to the fact that the diaphragm is not essential to life. One should never lose sight of the fact that complete absence of the diaphragm is normal in all animals below mammals.[2] It is of interest that a bird such as the ostrich, which is noted for its strength and endurance, has no diaphragm. In one of the cases recorded here, it is to be noted that the patient was able to enter into athletic contests and, among other events, was a successful entrant in a 5 mile relay race.

On roentgen-ray examination the appearance may closely simulate eventration of the diaphragm (fig. 3). In cases of thoracic stomach (fig. 4), a misinterpretation is also possible. The differential diagnosis can be made only by the aid of direct lateral roentgenologic examination. In this position in the normal person, both the right and left leaves of the diaphragm can be seen throughout their entire extent; hence, the absence of one leaf or a portion of it can be readily determined. In eventration of the diaphragm, no matter how thin or how high the outline of the diaphragm, it can be distinguished.

The exact recognition of congenital absence of the left half of the diaphragm is extremely important from the surgical standpoint, as the condition does not lend itself readily to surgical repair. In a case reported by Clayton-Greene, total absence of the left half of the dia-

1. Harris, W., and Clayton-Greene, W.: Congenital Absence of the Left Half of the Diaphragm, Simulating Pneumothorax, Proc. Royal Soc. Med., 1911-1912, p. 153.

2. Colton, B. P.: Zoology, Boston, D. C. Heath & Co., 1909, p. 283.

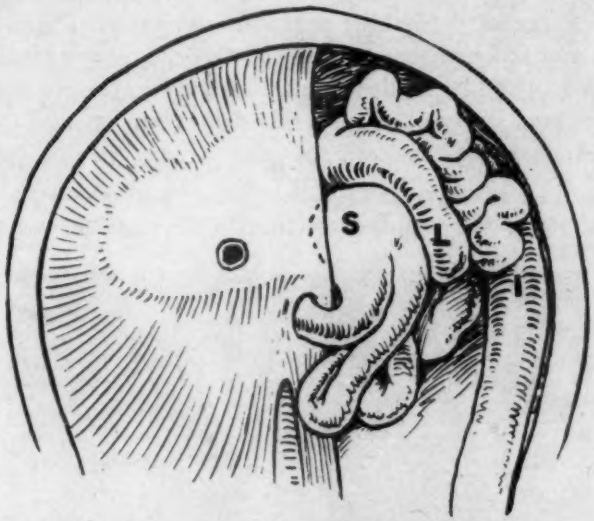

Fig. 1.—Abdominal aspect, showing absence of left half of diaphragm diagrammatic. (From J. B. Hume, London; specimen preserved in the museum of St. Bartholemew's Hospital, London.)

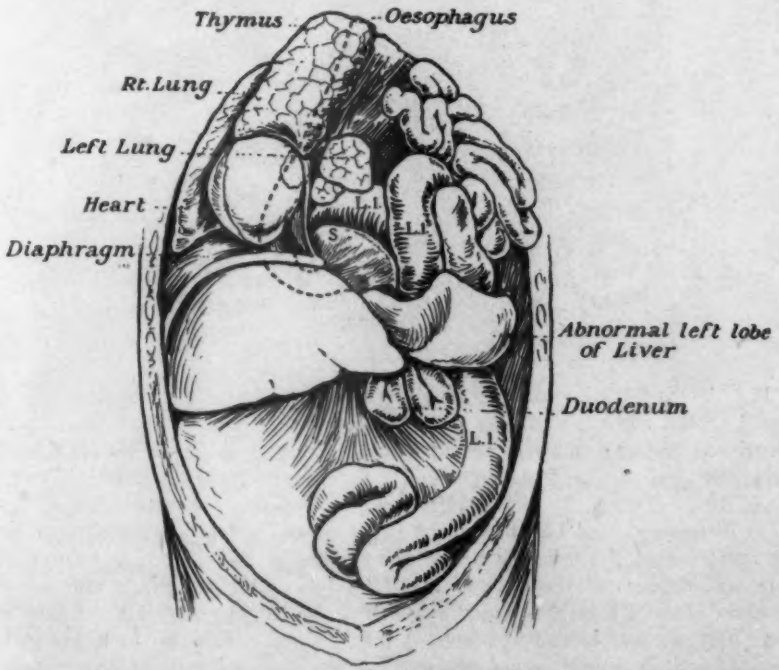

Fig. 2.—Absence of the left half of the diaphragm in the same case as figure 1, showing the course of the esophagus by the dotted lines: *S*, stomach; *L. I.*, large intestine. (From J. B. Hume, London.)

phragm was found following an operation for supposed diaphragmatic hernia. The operator found it impossible to bridge the defect in the diaphragm and accomplished nothing by the operative procedure. Had the case been carefully studied roentgenologically, the correct diagnosis could have been arrived at and the dangerous operative procedure avoided. A report of this case follows:

A woman, aged 31, 5 feet, 10 inches tall, strongly built and heavy, had been married five years, and had two children. Five years previously, she had

Fig. 3.—Eventration of the diaphragm on the left side: the heart is displaced to the right, simulating dextrocardia; the stomach, however, is on the left side. Autopsy showed absence of all muscle tissue in the left leaf of the diaphragm.

fallen downstairs and had broken two ribs on the left side. Four years later, she again jarred the left side badly when motoring. On physical examination, there was dulness at the base of the left lung. Roentgen-ray examination of the chest showed a sickle-shaped shadow at the left base, with a brilliant area above and internal to this shadow. A diagnosis was made of localized pleural effusion with localized pneumothorax and partial collapse of the left lung. Later, a diagnosis of hernia of the diaphragm following rupture due to the fall was made, and an operation was undertaken. A total absence of the left side of the diaphragm was found.

Keith,[3] in his article on diaphragmatic hernia, records three cases of congenital absence of one side of the diaphragm in the fetal stage and one case similar to Clayton-Greene's case. The ability of a person to survive with diaphragmatic hernia or congenital absence of the left side of the diaphragm is proved by one of Keith's patients who lived to be over 70 years of age, and one of mine who is 62.

Meyer [4] reports a case of congenital absence of the left half of the diaphragm in a new-born lamb which had survived birth but a few

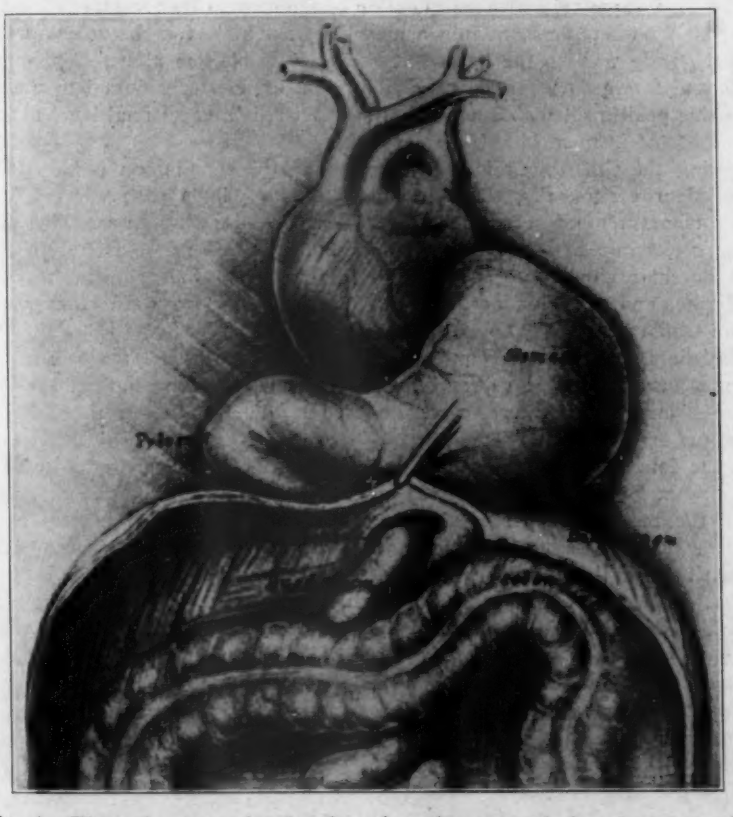

Fig. 4.—Thoracic stomach, showing that the stomach has been completely developed above the intact diaphragm. The duodenum passes through the opening in the diaphragm which would normally be the esophageal orifice.

moments. When the abdomen was opened, the most striking feature was the absence of the larger portion of the intestines, which made the abdomen seem comparatively empty. Further examination showed the greater portion of the left half of the diaphragm to be absent, allowing

3. Keith: Brit. M. J. **2**:1297, 1910.
4. Meyer, A. W.: Spolia Anatomica, J. Anat. & Physiol. **9**, 1914.

over half of the small intestine, the cecum, a portion of the large intestine, practically all of the distended rumen, the spleen and part of the pancreas to pass into the left pleural cavity. The left lung, which was totally collapsed, was only about half normal size. The mediastinum, esophagus, aorta and apex of the heart were markedly displaced toward the right side.

Hume [5] gives an excellent description of the development of the diaphragm:

> The diaphragm arises by modification of the septum transversum of the early embryo. This septum is mainly a mesoblastic vehicle for the ducts of Cuvier from the body wall to the heart. It occupies an oblique plane, sloping downwards and forwards from the cervical region, immediately dorsal to the heart. From this position it makes a gradual descent, reaching its final level about the third week of intra-uterine life.
>
> During the third week it has a posterolateral opening on either side, the hiatus pleuroperitonealis, through which the lung buds pass upward, as the septum transversum descends; the pleural cavity thus being an extruded portion of the coelom. As the septum transversum descends, mesoblastic cells in the lower dorsal region, representing the cephalic end of the primitive mesentery, proliferate, and, bridging across the opening, establish a connection with the septum transversum.
>
> The diaphragm is thus constituted of a ventral portion derived from the septum transversum, and a dorsal portion derived from the primitive mesentery. In the primitive mesentery, near its free border, is placed the developing esophagus and stomach.
>
> In the fourth week the hiatus pleuroperitonealis is closed by a double fold of pleura and peritoneum. Muscle fibers are now present in the septum, but not in the membrane closing the hiatus. This can be seen macroscopically from the fifth to the twelfth week as a transparent triangular area situated between the costal and spinal muscle origins.
>
> The thinnest portion of the rest of the diaphragmatic sheet is the central area of each dome. The right dome is completely filled by the liver, while the left contains a small portion of liver, the stomach and coils of intestine of the proximal and distal loops of the midgut, which are undergoing rotation about the axis of the vitelline artery. The grouping of intestine in this region is due to the fact that this is the most roomy part of the abdominal cavity, the anteroposterior diameter of the lower abdomen being much less and the pelvis merely a potential space.
>
> . . . Congenital hernia occurs through the left dome most commonly . . . and is due to some primary congenital ectopia of viscera, occurring at the time of formation of the diaphragm, and sometimes associated with incomplete rotation of the intestine (fig. 5).

In describing congenital diaphragmatic hernia, Hume states:

> Complete absence of the left half of the diaphragm is not infrequently found in fetal cases. The whole diaphragm to the left of the esophageal opening and the left crus is absent. Parietal pleura and peritoneum form a continuous

5. Hume, J. B.: Congenital Diaphragmatic Hernia, Brit. J. Surg. **10**:207-215 (July) 1922.

sheet. Abnormal lobes or semidetached portions of the liver are frequently found, and the greater part of the intestine, in a partially rotated condition, lies in the chest. Such a condition is almost always incompatible with life, though it is recorded that one boy lived to the age of 17 years.

In view of the apparent lack of recognition of congenital absence of the left half of the diaphragm, owing to confusion with diaphragmatic hernia and eventration of the diaphragm, the following three cases are

Fig. 5.—Hernia through a large defect in the left dome of the diaphragm: The inverted position of the stomach (*S*) in the chest cavity should be noted; the cecum, transverse colon and splenic flexure (*L. I.*) also are in the chest cavity. An erroneous roentgen-ray diagnosis was made of "complete pneumothorax, left side, the left diaphragm considerably higher than the right." (From J. B. Hume, London; specimen preserved in the museum of St. Bartholomew's Hospital, London.)

recorded, together with the necropsy reports in a fourth case. As far as known, cases 1 and 2 are the first two cases in which the roentgen-ray diagnosis of congenital absence of the left half of the diaphragm has been made.

Case 1.—J. M., a Scotchman, aged 31, referred by Dr. W. A. Downes, had had distress in the intestinal tract, with gas, which had started as a chronic condition but had become acute. During his high school period, in spite of a diagnosis of dextrocardia, he had engaged in the usual amount of athletics, such as running and football. He had had several roentgen-ray examinations for disturbance around the heart, but the condition of the diaphragm was not recognized until it was observed by another roentgenologist; he, however, diagnosed the condition as eventration.

Fig. 6 (case 1).—Lateral view of absence of left half of diaphragm in a man, aged 31: *R. D.*, position of right side of diaphragm. It should be noted that no shadow of the left side of the diaphragm can be made out, as it is absent.

Roentgen-ray examination disclosed a deficiency in the left side of the diaphragm with the entire ileum, greater portion of the jejunum and the first half of the colon in the chest cavity (figs. 6 and 7). This condition was apparently associated with nonrotation of the colon. The stomach was ptosed, occupying an extremely low position in the abdomen. In spite of the low position of the stomach and the abnormal position of the intestine, the stomach emptied in five hours, at which time the meal was entirely in the left side of the chest cavity. There was no evidence of a limiting membrane or sac about the colon. Examination of the chest showed the right border of the heart

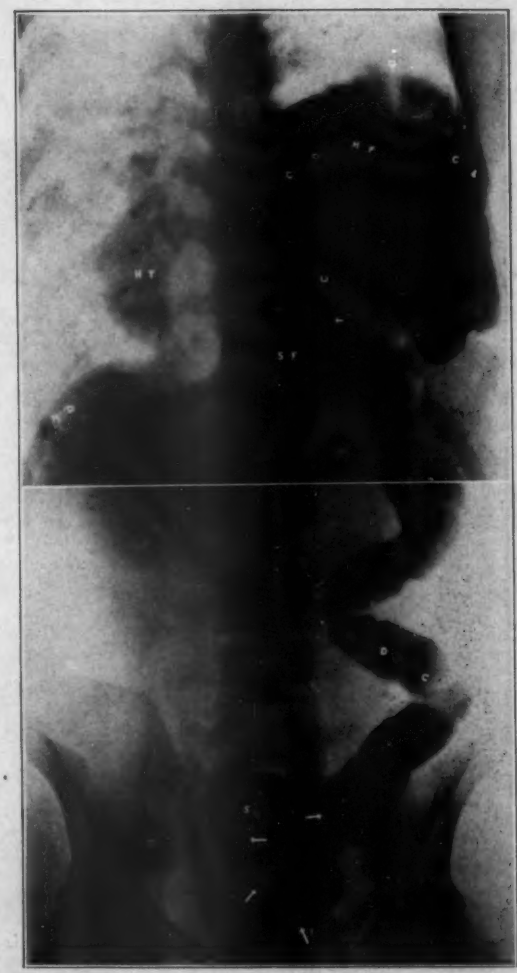

Fig. 7 (case 1).—Absence of left half of diaphragm in a man, aged 31: It should be noted that there is no shadow of the diaphragm on the left side; the terminal ileum, the cecum, appendix, ascending and transverse colon and the hepatic and splenic flexures are all in the chest cavity on the left. In some respects, this may be regarded as nonrotation of the colon associated with absence of the left half of the diaphragm; the heart is displaced to the right, but is not transposed.

to be about 4.5 cm. to the right of the median line. The apex was obscured by an area of density which was continuous with and about equal in density to that of the abdomen. The left side of the diaphragm could not be seen. The trachea was slightly more to the right of the midline than is usual. Both lungs showed a normal appearance, with an unusual amount of pulmonary area on the right side.

Six years later, this patient was alive and expressed himself as being "marvelously well." He also stated that he believed that he had less of the ordinary distress and stomach trouble than the average normal person.

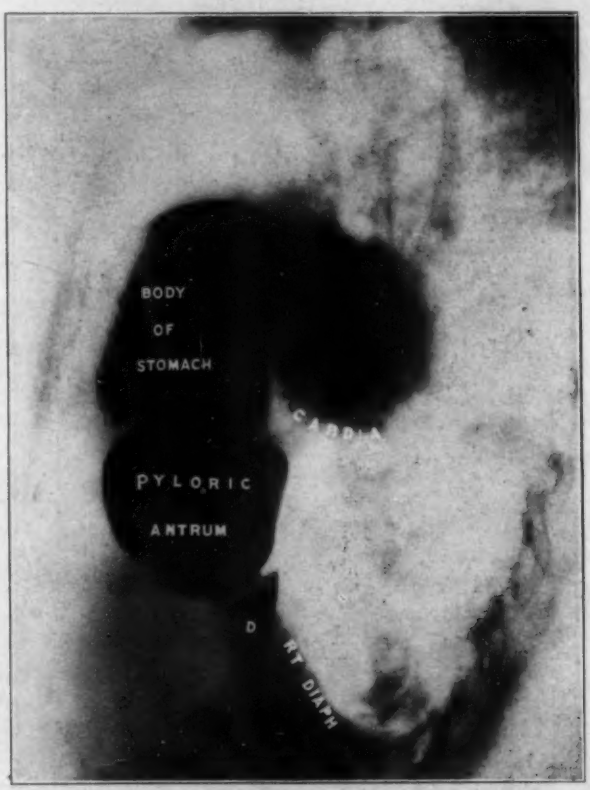

Fig. 8 (case 2).—Lateral view of absence of left half of diaphragm in a woman, aged 62; the right side of the diaphragm is visible, but the left side is absent; the stomach shows a remarkable appearance, being inverted. Note similarity to figs. 2 and 5.

Case 2.—A. R., a woman, aged 62, referred by Dr. Mills Sturtevant, complained mainly of coughing a great deal and of pain through the shoulders. For about six years she had had discomfort and pain in the midepigastric region after eating. The patient had had a roentgen-ray examination prior to the time I saw her, after which she had been told that she had a "double stomach" which would require surgical treatment.

Roentgen-ray examination showed the stomach to be inverted (fig. 8) and to be situated in the left side of the chest. The small intestine was entirely in the abdomen. The cecum was extremely low in position, but the splenic flexure of

the colon was in contact with the stomach in the left side of the chest. There also was evidence of multiple diverticula of the pelvic colon (fig. 9). The lungs showed evidence of chronic interstitial pneumonitis of nontuberculous nature, associated with chronic bronchitis, but without the presence of bronchiectasis. It is believed that the patient's cough was due to the condition of the lungs, and that the condition of the diaphragm was purely incidental.

CASE 3.—G. P., a man, aged 37, referred to Willard Parker Hospital from the occupational clinic of the Board of Health of New York City, had a roentgenographic appearance similar to that observed in cases 1 and 2 from a

Fig. 9 (case 2).—Lateral view of absence of left half of diaphragm in a woman, aged 62: The right side of the diaphragm is visible but the left side is absent; the splenic flexure of the colon is in the chest cavity. Arrows indicate diverticula of colon.

postero-anterior exposure. Effort has been made to obtain lateral exposures, but up to the present time this has not been accomplished. The case is therefore believed to represent congenital absence of the left side of the diaphragm, unless proved to the contrary on further study.

CASE 4.—A Scotchman, aged 47, was referred to me by Dr. Robert Abbe with a request to make a roentgen-ray exposure six hours after Dr. Abbe had given the patient an opaque meal. The roentgen-ray exposure revealed no evidence of an opaque substance in the abdominal cavity, an observation

identical with that in case 1. No fluoroscopic or chest examination was made. Hence the fact was not determined that the opaque substance was all in the chest cavity at this time, as was observed in case 1.

A brief summary of the case as reported by Dr. Vogel [6] is:

The patient complained of abdominal pain and showed symptoms referable to stenosis of the large intestine. Necropsy revealed a large defect in the left side of the diaphragm. The left border of the heart was 2.5 cm. to the right of the midline; the right border was 11.5 cm. to the right of the midline. A considerable portion of the colon, including the cecum and appendix, together with the stomach and spleen were in the chest cavity (fig. 10). The opening in the diaphragm measured 6 inches (15.2 cm.) in diameter. There was no hernial sac. The sigmoid flexure showed evidence of diverticulitis, with marked inflammatory reaction and stenosis.

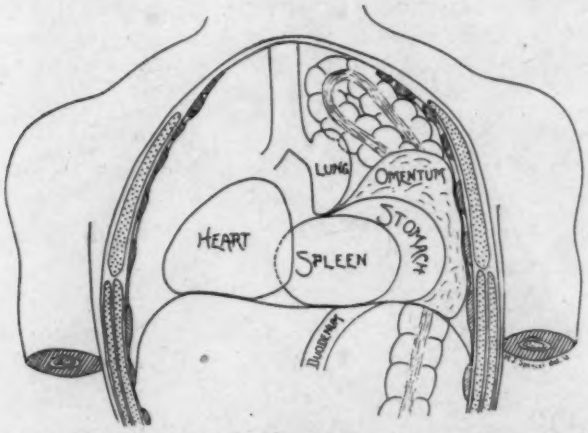

Fig. 10 (case 3).—Appearance at autopsy in a case of a large defect, 6 inches (15.2 cm.) in diameter, in the diaphragm. The contents of the chest were similar to those in a case of complete absence of the left side of the diaphragm.

Vogel reports the case as one of "false congenital diaphragmatic hernia" in view of the absence of a sac. In view of the large size of the defect in the diaphragm, this case might well be classified with the cases of congenital absence of the left half of the diaphragm. In this respect it closely resembles cases 1 and 2. It is also interesting to note that case 1 also occurred in a Scotchman and case 2 was complicated by multiple diverticula of the colon, as was also case 1.

The necessity for making a thorough fluoroscopic and roentgenographic examination in all cases of obscure symptoms referable to the abdomen or chest is illustrated by this case in which a limited roentgen-ray examination was made at the special request of the attending surgeon.

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6. Vogel, Karl: Diaphragmatic Hernia, with Report of a Case, Am. J. M. Sc. **145**:206 (Feb.) 1913.

No discretion was allowed the roentgenologist to make a complete examination, which prevented making a correct antemortem diagnosis in this case.

Vogel himself, in commenting on false congenital diaphragmatic hernia, called attention to a case by Klebs [7] in which the diaphragm was totally absent, yet the child lived until he was 6 years of age.

DIFFERENTIAL DIAGNOSIS

Differential diagnosis between eventration of the diaphragm and congenital absence of the left half of the diaphragm can be made roentgenologically, especially in lateral exposures. In eventration, however high the diaphragm may be, its outline can be seen. In congenital absence of the left side of the diaphragm, while the upper border of the stomach or portion of the colon may have a domelike appearance at times, repeated examination will show a change in the contour of these shadows.

Two cases of thoracic stomach have been examined by me and one case was confirmed by operation. Thoracic stomach is a term used particularly by Bailey [8] to indicate the presence of the stomach in the chest cavity without any evidence of an abnormal opening in the diaphragm. In both of these cases it was a simple matter to demonstrate the entire intact diaphragm on each side of the chest, and at no time could any portion of the stomach be found below the diaphragm. Furthermore, no other abdominal structure was found above the diaphragm at any time. These observations would serve to distinguish a case of thoracic stomach from either a true diaphragmatic hernia or a congenital absence of a portion of the diaphragm. This condition has also been described as diaphragmatic hernia of the stomach with short esophagus,[9] and other observers have called attention to the fact that this type of anomaly of the stomach is such that it is impossible to bring the stomach down into the abdominal cavity. However, it may at times be necessary to relieve some condition of the stomach itself, in which case the operative procedure would be undertaken through the chest cavity; or, as in a patient operated on by Downes, a gastro-enterostomy may be performed through what would ordinarily represent the esophageal orifice in the diaphragm. This case in a boy, aged 7 years, is the first one recorded in which a correct diagnosis of thoracic stomach was made by roentgen-ray exami-

7. Klebs, reported by Eppinger: Allgemeine und specielle Pathologie des Zwerchfells, Supplemente H. Nothnagel's Specielle Pathologie und Therapie, Vienna, 1911.

8. Bailey, P.: Anat. Rec. **17**:107-109 (Oct. 20) 1923.

9. Fineman, S., and Conner, H. M.: Right Diaphragmatic Hernia of the Short Esophagus Type, Am. J. M. Sc. **167**:672 (May) 1924.

nation. In the second case, that of a woman, aged 69 years, the correct diagnosis of thoracic stomach was made on roentgen-ray examination.[10]

In differentiating congenital absence of the left half of the diaphragm from a true diaphragmatic hernia, roentgen-ray examination is believed to be reliable, but should always include examination in the lateral position, as in this position the diaphragm can be made out if present. The latter fact is particularly true in hernia through the esophageal opening, a condition that is being recognized with increasing frequency on careful roentgen-ray examination of the digestive tract.

CONCLUSIONS

Congenital absence of the left side of the diaphragm is a rare condition but should never be confused with true diaphragmatic hernia, eventration of the diaphragm, or thoracic stomach.

The question of operability depends on the size of the congenital defect. In cases of complete absence of the left half of the diaphragm, it might be necessary in a particular case to operate for some complication, such as acute or chronic appendicitis, in which case the exact location of the appendix should be determined by means of the roentgen ray, and a suitable incision made at the nearest point. After undertaking the necessary surgical procedure, no attempt should be made to remedy the defect.

Congenital absence of the diaphragm is not incompatible with longevity.

In cases of traumatism to the abdomen or chest, congenital absence of the left side of the diaphragm should always be borne in mind and recognized in contradistinction to a supposed diaphragmatic hernia.

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10. Lewald, L. T.: Thoracic Stomach, Differentiation from Eventration and Hernia of the Diaphragm, Radiology **3**:91 (Aug.) 1924.

THE PHYSIOLOGIC EFFECT OF PHRENIC NEURECTOMY *

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The use of phrenic neurectomy in the surgical treatment of pulmonary tuberculosis has enjoyed increasing popularity within the last two years. It is not especially a new operation, nor is it one that is usually adopted alone, but rather in association with other surgical procedures. All work of this type is designed to give the lung its maximal amount of rest. Similar, although less, work has been done in nontuberculous cases.

In a general way improvement has been reported, but the presence of lesions within the lung has made it almost impossible to know whether or not the operation in itself will produce an appreciable alteration of the physiology of respiration.

It seemed necessary to determine experimentally the exact effect of the operation on the well-being of the patient in general as well as on his respiration. Accordingly, the normal functions of healthy animals (dogs) were observed. This included careful observation of the symmetry of the chests and the movements of the thoracic wall and diaphragm. They were operated on under ether anesthesia and with aseptic technic and the phrenic nerve was evulsed, some on the left side and others on the right, and, in one instance, on both sides. Great care was taken in the details of the surgical technic to expose the nerve beyond the point of its accessory roots, so that complete phrenic neurectomy could be effected. No immediate change was observed in these animals during the operation, and on the day following, when the animal had recovered from the anesthetic, the studies reported here were made.

To measure and compare the movements of each side of the thorax accurately, a special frame was built which could be securely fastened to a horizontal table. The horizontal bar, clamped to the table, was divided into two equal parts, and chains were fastened at its central point. Hooks were inserted into the lateral uprights at equal heights so that the height on the two sides could always be the same. The dog was placed on its back with its vertebrae exactly in the middle of the frame. The receiving tambours were fastened to the animal's thoracic wall by chains, the links of which were of equal length. By this means the

* Work done in the Division of Experimental Surgery and Pathology, The Mayo Foundation.

receiving tambours could be fastened to the horizontal bar by a chain of exactly the same length on the two sides. From the upper hook of the tambours other chains passing across the front of the chest could be fastened to hooks of equal height on the opposite upright. With such an apparatus it was possible to keep the tension on the two tambours exactly the same. The movements of the two sides were recorded simultaneously by recording tambours on the kymograph. Thus, a record could be kept and the observations of clinical examination confirmed. After the observations both by physical examination and tambour readings had been completed, the animals were observed under the

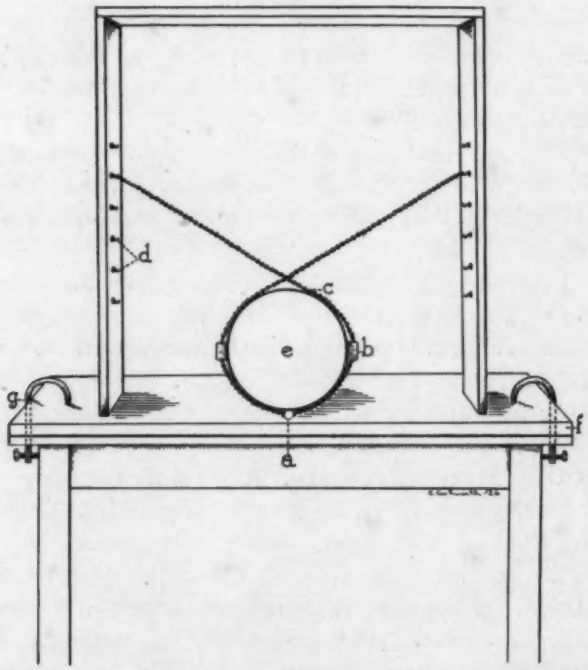

Fig. 1.—Dog in apparatus: *a*, central hooks for attachment of side chains; *b*, tambour; *c*, side chain attached to opposite upright; *d*, hooks equally spaced, measured from bottom upward; *e*, dog on back; *f*, base board; *g*, clamps to fasten to table.

fluoroscope and roentgenograms made of the chest. To preserve uniformity in the latter, roentgenograms were always made at the height of inspiration. This was easy of accomplishment because it was necessary only to hold the nose of the dog when the lung was expanded. There was always sufficient time to take a satisfactory roentgenogram. After all records had been completed, the animals were killed and studied at necropsy to determine whether or not pathologic changes were apparent (fig. 1).

EXPERIMENT SHOWING AMPLITUDE OF MOVEMENT OF EACH HEMITHORAX

Normal dogs were chosen, placed comfortably on their backs on a table and securely fixed in position. They were carefully examined, especially by inspection, and no difference in amplitude of movement of the two sides could be detected. For purposes of illustration, they were placed in the special frame, tambours under equal tension were placed against their sides and a record made of the movements of each hemithorax. All of the records were a confirmation of the observations made during the original examination. The two sides showed an even amplitude of movement. On fluoroscopic examination the amplitude of movement of the diaphragm was found to be equal on the two sides. Roentgenograms of the chest were made with the chest in the position of full inspiration and the record kept for illustration and comparison with others made later when the phrenic nerves had been evulsed.

EXPERIMENTS TO DETERMINE EFFECT OF AN ABDOMINAL INCISION ON MOVEMENTS OF CHEST WALL AND OF DIAPHRAGM

Animals found normal in the previous series of experiments were anesthetized and a long incision, such as is customarily employed for an Eck fistula operation, was made through the abdominal wall. Intra-abdominal manipulation was avoided. The wound was closed according to the standard technic and the animal taken to its cage. The following day after careful physical examination records were made. Fluoroscopic examinations were made in each instance. These experiments were repeated with dogs on which an Eck fistula operation had been performed on the preceding day.

Physical examination showed clearly that the abdominal movements were decreased in excursion but that those of the chest were not altered appreciably; nor were differences seen in any instance in the movement of the two sides. These observations were confirmed by a study of the tambour records, which showed an equality of movement on the two sides, as well as by fluoroscopic examinations which revealed normal equal movement of the two sides of the diaphragm. There was no instance in which either the movements of the chest wall or of the diaphragm were influenced by the abdominal incision.

EXPERIMENTS TO DETERMINE EFFECT ON MOVEMENT OF CHEST WALL AND OF DIAPHRAGM AFTER SECTION OF PHRENIC NERVE

Dogs found to have normal movement of the chest wall and of the diaphragm in former experiments were operated on under general

anesthesia and standard surgical technic. The phrenic nerve was isolated and carefully traced so that all tributaries might be identified. It was then drawn upward and cut off or evulsed, and the wound closed. Observations were made the following day. In every instance, physical and fluoroscopic examinations and tambour records were made.

Inspection of the chest invariably failed to show the slightest departure from normal. After the wounds had healed and the scars of operation were no longer apparent, several animals were brought to the examining room. Some were normal; in others the right phrenic nerve had been cut, in others the left phrenic nerve, and in one both phrenic

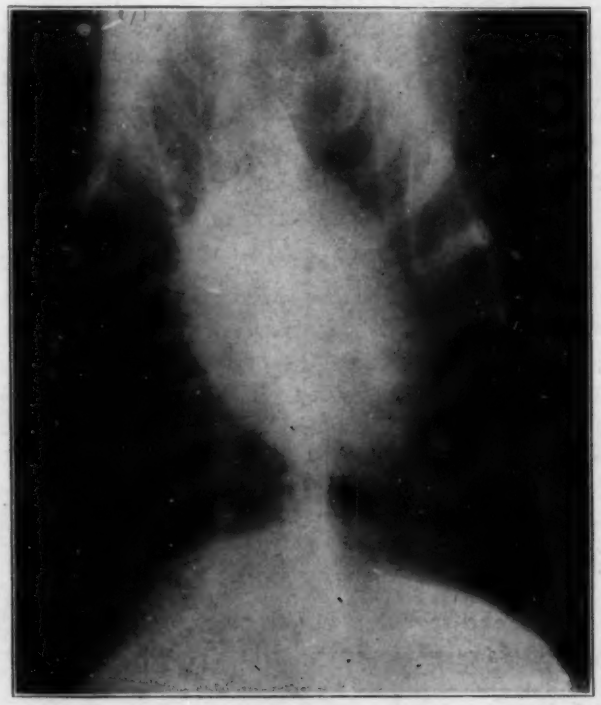

Fig. 2.—Right phrenic neurectomy; right phrenic nerve cut, showing elevation of the right side of the hemidiaphragm.

nerves had been cut, yet by observation it was impossible to distinguish the normal animals from those subjected to operation, and equally so to determine among the latter group which side had been operated on.

By percussion it was possible to locate the side of the severed nerve because of the higher area of dulness on that side, the lessened excursion of resonance during respiration and the slight departure of the heart from its normal position. It was impossible to determine the side of operation by means of the kymograph record. In each instance the tambour

record showed the same amplitude of movement of the two sides of the chest wall. On fluoroscopic examination, however, striking differences were observed. The paralysis on the side of operation was apparent. Not only did that half of the diaphragm fail to move through its ordinary excursive distance but in most instances it took on paradoxic movements, passing upward on inspiration and downward during expiration. These movements, however, were always very short. Often no movement could be seen and infrequently the movements were normal in direction but showed only a small fraction of the normal excursion. The other and unaffected half of the diaphragm showed an excursion that

Fig. 3.—Left phrenic neurectomy, showing elevation of diaphragm on the left side.

was identical with its movement before the operation had been performed. In no instance could a difference in the movement of the costal margins be observed regardless of which half of the diaphragm was paralyzed or when both phrenic nerves had been evulsed (figs. 2, 3 and 4).

Section of the phrenic nerve produces paralysis of that side of the diaphragm to which it supplies motor innervation. The paralysis affects the movement of the hemidiaphragm causing it to remain stationary or to have slight normal or more frequently paradoxic movements. The

diaphragm on the unaffected side moves normally through its customary excursion.

In this way, respiratory movements are shortened in one direction because the length of the thoracic cage is decreased. In no other direction are changes apparent. Not only the unaffected half of the diaphragm moves through its normal cycle but the thoracic wall and the costal margins act independently and move without restriction through their normal cycles and in their normal directions.

Without the fluoroscope, the examiner is unable to decide which is the affected side, whether he employs inspection alone or inspection combined with palpation. Percussion of the lower borders of the lungs and the position of the heart give some clue to the affected side, but little

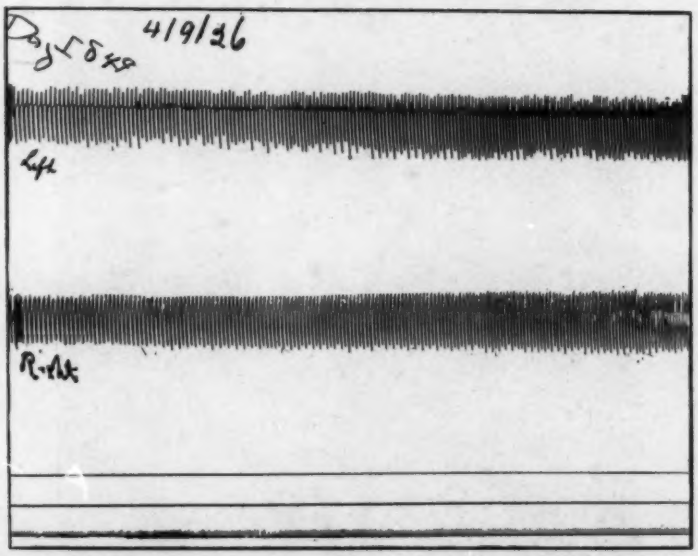

Fig. 4.—Right phrenic nerve severed; reading made with animal anesthetized with ether; movements of chest wall equal on two sides; normal outward movements of costal arches during inspiration. Paralysis of the right side of the diaphragm was seen on fluoroscopic examination; the right half of the diaphragm was found atrophied at necropsy; intrapleural pressure was equal on the two sides.

help is obtained by auscultation; the breath sounds are apparently unaltered and no evidence of congestion can be found. In examinations of animals several weeks after phrenic neurectomy, it was impossible to determine with exactness the side that had been operated on when only physical examination and tambour readings were available.

Dog 2 afforded a specific illustration of the common observations. Inspection, palpation and auscultation gave no clue to the side of operation. and the heart seemed to be in the middle of the chest. The animal

breathed mainly by means of costal movements, then slight movement of the abdomen, slightly accentuated on the right side. The left phrenic nerve had been severed. On fluoroscopic examination, however, the dome of the left hemidiaphragm was higher than the right ever reached and showed evidence of slight normal movement. The right half of the diaphragm maintained its normal excursion. The heart seemed to be in its normal position, and no alteration from the normal density of lung tissue could be observed.

Dog 1 illustrates the observations obtained when neurectomy has been carried out on both sides. His respiration was not embarrassed. He breathed normally with equal expansion on both sides. When the lungs filled, the abdomen relaxed, but when the lungs emptied the abdominal muscles contracted forcibly. One could not have suspected from the appearance of the animal that an operation had been performed which might have crippled respiratory function.

THE EFFECT OF PHRENECTOMY ON INTRAPLEURAL TENSION

It is well known that the mediastinal partition of a dog is a thin and fragile membrane, and that fluids as well as air may pass from one side to the other. Pressure, therefore, should be equalized regardless of the unilateral lesion inflicted, and the opposite side should sustain a burden in compensation so that respiration may be unimpaired.

It seems probable, therefore, that pressure readings in experiments on dogs cannot be interpreted as accurately portraying conditions in man, subjected to a similar experiment. Yet compensation is a fundamental function in all animals and concerns physiologic phenomena consequent on section of a motor nerve for the purpose of determining the crippling effect on respiration as a whole and on the relationship existing between the several groups of muscles whose concerted and correlated action makes breathing possible. To this end, simultaneous readings were made from each side, employing a pair of manometers mounted side by side (fig. 5).

The size of the animal and the character of its breathing during anesthesia seemed to affect the amplitude of movement and create greater or less variations between the two phases of respiration. Thus, it became difficult to establish a normal negative pressure reading that might apply to any animal or, in fact, to a single animal under varied circumstances. Yet the readings on the two sides were invariably approximately the same whether they were taken on normal dogs, on dogs with both phrenic nerves severed, or on dogs with only one nerve severed, and regardless of whether the right or the left nerve had been destroyed.

The accompanying table illustrates the variables and the similarities of the readings. The dogs were under ether anesthesia while readings

were being made. In each case, physical examination failed to disclose differences in breathing.

The readings taken on dog 5 were particularly interesting because of the perfect rhythm of respiration and the equality in depth of successive inspirations and expirations. The manometer levels were always identical, rising and falling in unison.

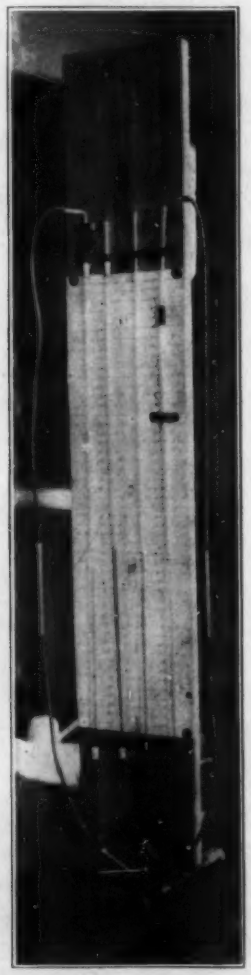

Fig. 5.—Two water manometers mounted side by side, each connected with needles of equal caliber. The needles were inserted at the same level in the axillary line and readings were taken in both inspiration and expiration.

When readings were taken on dog 3, in which the right side of the hemidiaphragm had been paralyzed, and had been seen under fluoroscopic examination to remain high in the thorax, the readings showed

certain variations with each respiratory movement. Thus, readings of separate respirations registered —4 to —8, —2 to —6 or —5 to —9, but in every case there was no difference between the two sides. In this particular animal, therefore, although certain variations were noticed, there were no differences between the affected and the unaffected sides. Compensation had been so complete that the two pressures were maintained equally; careful observation failed to disclose inequalities in respiratory excursions, and the costal margins moved through their normal excursions in both distance and direction, seemingly independent of the fact that one side of the diaphragm had its normal strength while the other had become a flaccid structure lying inert a full interspace higher than its mate.

Effect of Phrenic Neurectomy on Intrapleural Tension

Dog	Operation	Pressure (Mm. of Water)	
		Left	Right
1	Both nerves cut	—3.5 to —5.5	—3.5 to —5.5
2	Left nerve cut	—1.5 to —4.0	—1.0 to —3.5
3	Right nerve cut	—1.0 to —7.0	—2.0 to —7.0
4	Normal	—2.0 to —6.5	—2.0 to —6.0
5	Right nerve cut	0 to —8.0	0 to —8.0
6	Right nerve cut	—3.0 to —7.0	—2.0 to —7.5
7	Left nerve cut	—1.0 to —5.0	—2.0 to —5.5
8	Right nerve cut	+2.0 to —5.0	+2.0 to —5.0
9	Left nerve evulsed	+1.0 to —6.0	+1.0 to —6.0
10	Left nerve cut	+1.0 to —5.0	+1.0 to —5.0

The reading in the case of dog 10 was more difficult to obtain satisfactorily because different respirations gave different variations between the two sides. With certain respirations, one manometer reading varied as much as 1 mm. from the other; during the next respiration, an identical discrepancy might appear on the opposite side. There seems to be a certain degree of independence in movements of the two sides and not complete uniformity either for successive respirations on the one side, or for one side as compared with the other. The majority of respirations, however, are equal in amplitude and degree of negative pressure. During expiration, the pressure frequently registers zero or even small positive values.

FUNCTIONAL CAPACITY OF ANIMALS AFTER PHRENIC NEURECTOMY

In the foregoing experiment, it has appeared that compensation is so powerful a protective mechanism as to preclude the possibility of danger to respiration, even though an important muscular structure has been rendered incompetent to carry out its accustomed office. Anatomically, it becomes apparent that the only effect of paralysis of one side of the diaphragm is to lessen the long diameter of the thoracic cage. The

volume of the lung is decreased by lessening of one dimension only. It remains to be seen whether or not vital capacity is markedly impaired or whether abnormal or pathologic changes could be found in the lung.

These two problems were approached by an attempt to compare the functional capacity of the several animals with that of normal animals of approximately the same size and weight and subjected to the same strain. The second problem was studied by the gross and histologic appearance of the organs and will be discussed later.

No satisfactory mechanical device could be used to study the functional competency of respiration. It was decided that the capacity to do work would be an accurate index of respiratory competency. Accordingly, a distance of four-tenths of a mile was measured on a road that ran down a gently sloping hill. The animals operated on were each paired with a normal dog and then allowed to run down and back up the hill to the starting point.

It seemed to make no difference to the animal's ability to perform this strenuous exercise whether his phrenic nerve was severed or not, and one animal whose whole diaphragm had been paralyzed seemed to fare as well as his normal mate.

In three of the animals the phrenic nerve had been anastomosed with the recurrent laryngeal; these animals could be separated from the others because of the stridulous breathing. They were not in any way embarrassed, however, in their ability to perform the work. They ran freely and without evidence of fatigue or dyspnea. Two of them, in fact, were eager to run and actually dragged their more sluggish though normal mates.

A jury of disinterested observers, unacquainted with the animals used in the experiments, was unable to segregate the normal dogs from those subjected to operation except in the cases of those who had been subjected to combined operation on the phrenic and recurrent laryngeal nerves. Perhaps if the exercise had been so strenuous as to produce exhaustion, the normal dogs would have failed less quickly than the others. This was not done as it was desired to determine rather, whether the operation would produce a disability incompatible with the performance of the more nearly normal requirements of life. Compensation seems to be adequate to protect the respiratory function against failure during the performance of ordinary activities.

INFORMATION OBTAINED AT NECROPSY

The animals were killed by overetherization. Before death the tracheal overflow was obstructed in order to keep the lungs in an expanded condition. After death the thoracic wall was removed and the lungs were observed while still expanded. In one instance, namely, when both phrenic nerves had been severed, passive congestion was seen at

the bases of the lungs and throughout the posterior surfaces of all of the lobes. In all the other animals, the lungs appeared perfectly normal. The phrenic nerve was traced in each instance throughout its course to determine whether or not accessory branches had been missed during the surgical operation. In one instance, a tiny twig was found passing into the main trunk below the point of section. The condition of the pericardium and heart was observed, but pathologic changes were not noticed, and, as in the pleura, no increased amount of fluid was found. The diaphragm itself showed striking changes. One animal that was killed within two days of its operation showed evidence of atrophy which was observable in the gross specimen and represented by pallor and thinning of the muscle. The diaphragm on the side of operation was approximately one interspace higher than on the opposite side, and in those animals that had been under observation for as long as three months the muscle was only a fraction of the thickness of that of its mate, pale and almost transparent. Even the hemidiaphragm in the animal that had a small unsevered branch showed marked evidence of atrophy and could scarcely be distinguished from that of other animals in which the phrenic nerves had been evulsed completely.

Sections were taken from the posterior portion of the lower, middle and upper lobe of both sides, from the phrenic nerves on the two sides and from both sides of the diaphragm. No difference could be determined on microscopic examination of these sections of the lung. Apparently no pathologic change had resulted from the neurectomy. In the one instance in which both nerves had been sectioned, evidence of passive congestion was seen. Sections from the phrenic nerves on both sides were studied under the microscope; a comparison showed definite evidence of atrophy of the nerve fibers when differentially stained. The muscle was also atrophied in all instances on the side of operation, but remained perfectly normal on the intact side.

To emphasize the effect of phrenic neurectomy a description of the observations in one case after operation and at necropsy is included. A dog was operated on, April 13, at which time the right phrenic nerve was drawn up as far as possible and evulsed. The animal was studied in the usual way. On physical examination, there was such similarity between the two sides that the side of operation could not be distinguished from the normal; the dog's physical fitness to do work was unimpaired and its intrapleural pressure was satisfactorily recorded and was bilaterally equal. The fluoroscopic examination showed that the right hemidiaphragm was paralyzed, rose an interspace higher into the thorax than the left and displayed short paradoxic movements.

On September 11, the dog was reexamined and the observations just described were confirmed. He was anesthetized with ether for twenty minutes, during which time iodized oil, 40 per cent, was slowly intro-

duced into the trachea. Ten minutes later he was killed by overetherization, the trachea being clamped to maintain expansion of the lungs. The lungs and heart were carefully removed without injury to the diaphragm or its attachments. The lungs appeared normal in every respect; there was no evidence of congestion on either the dorsal or ventral sides or in the upper or lower lobes.

Fig. 6.—Appearance by transmitted light, showing the relative thickening of the two sides and the translucency of the paralyzed hemidiaphragm.

The left phrenic nerve was normal in size, and mechanical stimulation of its distal end caused marked muscular contraction of the diaphragm. The right phrenic nerve, however, was smaller than normal and terminated above in a scar attached to the upper portion of the

pericardium. Similar stimulation of its distal end produced no response of the atrophic muscle.

The abdominal contents were carefully removed, leaving the diaphragm intact. Then light was thrown in from the abdominal side and a most striking picture presented itself. The left hemidiaphragm was almost opaque and showed only its bright red color, but the right was pinkish, thin and transmitted light so that objects could easily be seen

Fig. 7.—Appearance by direct light, showing detail of normal muscle and the line of demarcation between the normal and the paralyzed side.

through its muscular portion. Moreover, it was seen that this advanced degree of atrophy was not confined to any one portion but included the whole muscular structure of that side, proceeding from the middle line, where it was precisely separated from the normal, to the periphery where

it was attached to the thoracic wall. The paralysis had evidently been complete, and the atrophy was universal.

The diaphragm was then removed intact and flattened out smoothly on a ground glass plate. Fibrillary twitchings appeared in the thick red muscle of the normal side, but the paralyzed side was in repose and could not be made to show muscular movements by stimulation applied

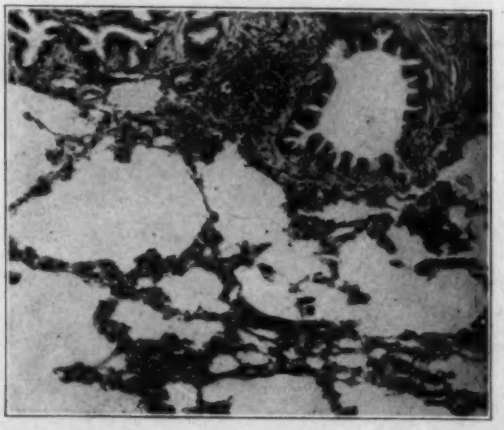

Fig. 8.—Normal appearance of base of right lung in animal with right phrenic nerve cut.

Fig. 9.—Atrophied nerve, showing vacuolization and loss of myelin sheath.

to the stump of the phrenic nerve or directly to the muscle itself. Yet either procedure brought out violent contraction on the normal side. The line of demarcation was nicely illustrated by this means and confirmed the observations made on inspection. Contractions occurred up to the line of separation when the normal muscle was stimulated, but

ceased abruptly when the same stimulation was carried beyond it. A distance of one-sixteenth inch on either side of the visible line of juncture of atrophic and normal muscle was sufficient to illustrate these observations. The failure of response to stimulation was uniform throughout the whole of the atrophic muscle from its juncture with the normal half to its peripheral attachment.

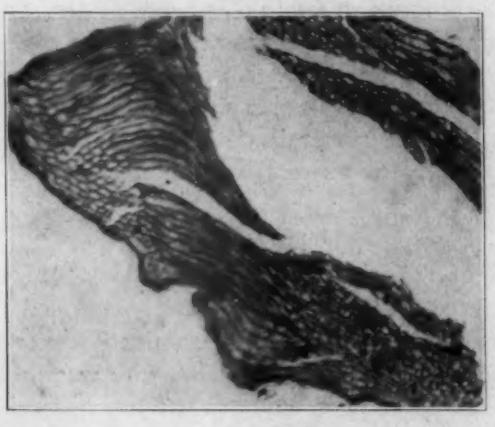

Fig. 10.—Normal phrenic nerve (separation due to technic of cutting).

Fig. 11.—Atrophic muscle fibers, reduced in size, and increased number and clumping of nuclei.

The microscopic appearance of sections taken from many portions of both sides was striking. Those from the normal half showed only normal striated muscle cells, but in every section from the paralyzed half the muscle cells were seen to be atrophic and smaller than normal, and the nuclei, therefore, appeared close together. When especially

studied fat droplets were seen; with van Gieson's stain specimens showed no evidence of increase in connective tissue. When the degree of atrophy was studied, a micrometer attachment was employed to measure the size of the cells. No effort was made to obtain absolute accuracy, but it was possible to determine that the atrophic cells were approximately one-quarter the size of the normal cells. This corresponds with the judgment of the relative thickness and density when inspected grossly. The sections of the lungs showed no evidence of abnormality regardless of the side or part of the lung examined.

The lungs were examined fluoroscopically when still inflated. Iodized oil, 40 per cent, had been aspirated into both the right and left sides, showing that the paralysis on the right side did not influence respiration sufficiently to prevent aspiration of the tracheal contents (figs. 6 to 11).

SUMMARY

In a series of experiments on dogs, either one or both phrenic nerves were severed. The behavior of the animal and the function of respiration were studied by physical examination, a recording device and the fluoroscope. The intrapleural pressure was measured on both sides. The lungs, diaphragm and phrenic nerves were examined at necropsy, both grossly and microscopically.

The operation itself is attended with little or no risk for the patient; it brings about no impairment of his functions in general or of his respiratory function in particular. The compensation is sufficient to overcome the loss in function of the half of the diaphragm or indeed that of the diaphragm as a whole when both phrenic nerves are severed; the animal is competent to carry on its usual activities without embarrassment or dyspnea. The thoracic wall, both laterally and at the costal margins, apparently moves independently and is not influenced in direction or extent by paralysis of the nerve regardless of the side operated on. Atrophy appears early in the diaphragm, but paralysis appears at once, and the paralyzed side can be determined by fluoroscopic examination, but not by inspection or palpation of the chest, nor by tambour readings of its movement. The paralyzed hemidiaphragm rises approximately one interspace higher than its fellow and remains stationary or takes on short normal movements, or in a few instances paradoxic movements so that it may be seen to rise in the thorax a short distance on inspiration and fall an equal distance on expiration. The paralysis on the side of the section is complete and the atrophy uniform. The line of demarcation between paralyzed and normal muscle is distinct and sharply drawn. The response to stimulation is lost throughout the whole of the affected hemidiaphragm. The muscle cells are reduced to approximately a quarter of their normal size, and fatty degeneration

was observed but no increase in connective tissue. It is possible that connective tissue might be increased in amount if the animals were allowed to live more than five months after operation. No observations were made over a longer period of time.

The experimental work would lead one to believe that respiration is a complicated mechanism, made up of the combined movements of various sets of muscles each so controlled that coordination of movement is maintained, yet each so independent of the other that it may be put into dysfunction without disturbing the action of any others, singly or combined. Compensation is highly developed and a factor of safety, so that the animal crippled by the loss of even so important a structure as the diaphragm may not only survive but be competent to live an active and a normal life. The alternative presents itself for consideration. It may be true that the importance of the diaphragm has been overestimated.

Section of one phrenic nerve causes paralysis and atrophy of the entire hemidiaphragm on the same side. After five months there is no evidence of cross innervation or of regeneration. Moreover, the evidence seems clear that the periphery of the diaphragm throughout its whole circumference suffers atrophy. If the branches of the intercostal nerves innervate this portion, their usefulness would appear to be extremely small and insufficient to prevent atrophy equal to that in other and remote areas, or to permit of contraction when the muscle is stimulated.

Paralysis of one half of the diaphragm fails to affect respiration to the extent that aspiration of tracheal contents is prevented. The size of the thoracic cage is decreased in one dimension only. This reduction of volume produces no physiologic alteration from normal.

THE LOGICAL SEQUENCE IN TWO-STAGE THORACOPLASTY

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In deciding on an operative course in cases of pulmonary tuberculosis, there should be a full review of the progress of the disease from the beginning and a particularly careful study of the rapidity and character of the changes that have occurred during the last two or three months. Treatment by pneumothorax will probably have been instituted and its result should be known. In addition to this clinical picture, a roentgenologic series is necessary. With all the data in mind, the type of operation or combination of operations may be selected from some kind of thoracoplasty, phrenic nerve avulsion, pneumonolysis or a direct procedure on the lung.

The favorite practice at the present time is to perform paravertebral thoracoplasty as elaborated by Sauerbruch, the details of which it is not necessary to review. This operation may be performed in one stage or in a series of stages, according to the pathologic picture and the patient's physical state or mental attitude.

The more usual manner of proceeding is to divide the thoracoplasty into two principal stages, the one beginning with the resection of the lower ribs, the other beginning with the resection of the upper ones.

The question I wish to take up here is the one of precedence. Following the advice of Sauerbruch, most surgeons have begun by operating on the lower part of the chest, and after an interval of days or weeks have resected the upper ribs, ending with the first.

In my earlier cases, I operated in one stage (five cases), resecting the first eight ribs only; but I soon came to the conclusion that the two-stage operation with resection of from ten to twelve ribs was preferable. The sequence having the upper part of the thorax as a first step was decided on after a study of the usual distribution of the pathologic lesions and the physiology of the movements of the chest wall in breathing.

I shall speak only of those cases in which collapse as complete as possible is contemplated, even though in the progress of the case it may be decided that a less radical procedure may suffice, with the treatment suspended after the first stage. Cases complicated by open empyema are not considered here because they demand a separate procedure—that of obliterating the infected pleural cavity, the lung itself already being collapsed or even compressed.

The danger of spilling by gravity from cavities in the upper part of the lung has been referred to as a reason for beginning with the lower

ribs, and this seems to be the principal theoretical ground for delaying the upper stage.

Briefly, the following are my reasons for preferring to resect the upper ribs first:

1. The advanced lesions, particularly cavities, are more frequent in the upper lobe, or even in the apex, than in the lower. The resection of the first five or more ribs has an immediate beneficial influence on the seat of the main lesions.

2. As the operation is performed under local anesthesia, the danger of overflow is practically nullified by the patient's voluntary effort to expectorate, the principal power of the cough being applied by the lower, more freely moving ribs.

3. The compression exerted on the contents of the chest by the mobilization of the upper ribs is more gradual than that which is encountered on resection of the lower ribs, because for obvious mechanical reasons it is practically impossible to exert direct force, as by a bandage, on the apical portion. The effect is secured partly by muscular action and partly by negative intrapleural pressure so that sometimes the final result is not obtained for weeks or even months after the operation. There is, however, an immediate and considerable reduction in the capacity of the apex, sometimes amounting to its obliteration, because the first rib almost always drops so that its distal cut surface is from one to two interspaces lower than the cut surface of its vertebral portion.

4. The physiologic changes due to the mechanics of the operation on the upper part of the thorax do not cause such serious derangements of function as those following the operation in the lower part of the chest, where the amplitude of respiratory motion is greater. The most serious of these derangements is displacement of the mediastinum toward the healthy side, and this is much less marked in the upper part of the chest than in the lower. When the time has arrived for the second stage, a partial adjustment to the altered state will have taken place so that there will be less shock from the displacement of the more mobile parietes in the lower part of the chest.

5. It is essential that the first rib should be resected in order to secure rapid and good collapse of the apex. Then, too, this rib is the keystone on which depends the drop of the ribs immediately below it, say the second, third and fourth, and there is doubtless an effect on the position of those lower down. Manifestly, then, the greatest possible reduction in the size of the hemithorax will not be secured unless this rib is cut. It should therefore be divided at the first stage, before the resected ribs below have become fixed in their new positions.

6. If the phrenic nerve of the same side has been avulsed previously, attack on the principal lesion by resections of the first five or six ribs

may produce such great improvement that it may be advisable to postpone indefinitely the thoracoplasty of the lower part.

7. The general rule of surgery, that other things being equal, the more difficult part of an operation should precede the simpler, may well be applied in thoracoplasty. The patient, also, will be relieved to feel that the worst is over, and he will approach subsequent operations with confidence.

ABSTRACT OF DISCUSSION

On the Papers of Drs. Lemon and Lilienthal

DR. EDWARDS S. WELLES, Saranac Lake, N. Y.: I want to argue with Dr. Lilienthal a bit about this incision on the clavicle down to the bone. I have not tried this one, but have tried one a little higher. I used the one Dr. Alexander recommends, which is 6 cm. above the clavicle and 6 cm. long, in a transverse direction. I have gone back to the up-and-down incision at the posterior border of the clavicle, with the lower end of the incision coming about 1 inch (2.5 cm.) above the clavicle. I used to make the cut about 2 inches long and have now reduced it to 1 inch or less. I have two little retractors which I put in, one each way, cutting merely enough to allow room for the retractors. I think the important thing is to find the nerve and nothing else, as Dr. Lilienthal says. He enters the incision and says the phrenic nerve and nothing else is here. At the point at which I enter, the phrenic nerve is present and nothing else, because of the way I do it. I lift the sternomastoid muscle out of the way, and some to a layer of fascia. Then I put in my finger before separating or doing anything further and feel the anterior scalene muscle. The nerve is crossing on that diagonally, from without inward. If one finds this muscle first and exposes it, he has the phrenic nerve and nothing else. If when one has pulled the sternomastoid muscle out of the way, he begins to split the fascia, he always find a little pad of fat on top of the muscle. If that is split through and dissected by a blunt dissection, it is always easy to go down on the inside of the muscle, miss it altogether, and find that the dissection has reached the vertebrae; or one can easily go down on the outside of the muscle and run into various things. If one puts his finger in right at the start and splits the fascia on the middle of the muscle, he invariably finds the nerve and nothing else. The incision should not be 2 or 2½ inches (5 or 6.7 cm.), as Dr. Lilienthal says, but not more than an inch long. As far as disfiguring scars in women are concerned, I do not think that it makes much difference whether there is a 1 inch scar an inch above the clavicle or a 1 inch transverse scar on the clavicle. If a woman wants to cover it up altogether, she has to wear a neckpiece in her dress, or something of the sort. If she is going to wear a low-necked dress, she will expose the clavicle anyway. I do not say that this is not all right, but I think the other method is fully as good.

One objection I have to Dr. Lilienthal's method is that in operating on the left side one runs more danger of hitting the thoracic duct than in operating an inch higher up. In one case I cut the thoracic duct, and I have heard of one or two others who have cut it. This is not as serious as books would lead one to expect, but one does not want it to happen. I should be a little afraid in operating on the left side by Dr. Lilienthal's method that if the thoracic duct arched a little above the clavicle, I might strike it in dissecting the phrenic nerve.

As far as drainage is concerned, I always used to drain as Dr. Lilienthal says. Now, when I make the small incision and blunt dissection described to reach the nerve, putting in no tie, I cut no vessels except in the skin. In the last twenty or twenty-five cases, I have put in one small subcutaneous suture, starting at one end of the cut, going back and forth and emerging at the top, with no drain. So far I have had no collection of serum inside that I have had to drain; there are no stitch holes after this method is used, and the scar is almost imperceptible.

As to Dr. Lilienthal's method of performing thoracoplasty, I think he is right. I believe that what he says about the lack of danger of pushing down secretions from the upper lobe cavities into the lower lobe is true, because the lower ribs are the ones used for coughing and expelling secretions. If the lower ribs are left intact, there is no danger of pressing secretions from the upper lobe down, because even if they do go down, the patient can cough them up. Patients cough much better after an upper stage thoracoplasty than after a lower stage operation. I have been doing most of my operations in that order lately, and have preceded practically all of them with a phrenicotomy. I think it is well to do a phrenicotomy first before attempting thoracoplasty downward. In the first place, the patient raises more easily after phrenicotomy and, as Dr. Lilienthal states, in a good many cases fewer ribs can be taken out. I have not had any cases in which I could resect only the upper five, but I have had a number of cases in which I could stop at about eight or nine, instead of resecting the full eleven; the diaphragm rose up as far as the ninth rib, or even to the eighth, and I found that after taking out the upper eight ribs and then making a roentgen-ray examination to see how much collapse there was, that I had reached the diaphragm and that it would be a waste of time to remove the ninth, tenth and eleventh ribs.

Dr. Lilienthal spoke of doing the worst stage of the operation first. Technically speaking, it is true that when one has the upper stage done he has completed the hardest job, as far as the surgeon is concerned, but I think the contrary is true as far as the patient is concerned. The lower stage is the dangerous one. It is all right to tell the patient that the worst stage has been done, provided the surgeon does not let himself believe that his worries are over. I find that patients do not have much shock after operations on the upper part of the chest or suffer much afterward. I do not think the upper stage is nearly as dangerous as the lower. The upper one should be completed and then the lower stage approached with fear and trembling if the patient is very sick. One should proceed cautiously and stop at any time that the pulse gets weak, because it is following the lower stage that mediastinal flutter and circulatory embarrassment occurs, if at all.

Dr. John L. Yates, Milwaukee: Dr. Lemon's pictures showed that in dogs as well as man the motor fibers conducting motor impulses to the diaphragm are not of necessity included in the main phrenic trunk in its cervical portion. If one operates on a series of patients to produce temporary block, one finds that three of five people have all the motor nerves in the main phrenic branch. In the other two some of the fibers transmitting motor impulses are distributed in accessory branches. The main branch may be one, two or three. In attempting to produce temporary block, it is necessary to operate on these patients on the fluoroscopic table. Dr. Welles' injunction to locate the anterior scalene muscle as soon as the incision is made is the keynote to success. After the anterior surface of this muscle has been cleared by blunt dissection, one can quickly tell by the size of this phrenic trunk whether accessory branches are

to be expected. If so, some of them will be placed mesially and some laterally to the muscle. With the use of the fluoroscope the operator can see the type and nature of excursion before operation and the effect on the diaphragm after he has crushed the main branch and the accessory branches are revealed. It is necessary to keep on crushing the accessory branches until the desirable end is attained; this is a paradox. Until that desirable end is obtained the maximum influence of the paralysis of the diaphragm is not obtained. There are distributions of nerves so atypical that exercises may not cause complete paralysis.

Dr. Lemon said his manometer readings were identical after paralysis of the diaphragm on one side. However, the dog has a thin pleura, and man has not. If Dr. Lemon would employ the same method but use an animal with a thick pleura like the monkey or sheep, he would find a material difference, and that that difference would be a considerable reduction but not an abolition of the intrapleural negative pressures.

We have been able to make some study of the degeneration of the human diaphragm. We know that the degeneration begins promptly, that at the end of the fifth week it is well advanced, and that motion of the diaphragm is recoverable six months after temporary block. We have tried to find out such means as would permit the induction of a temporary block, to avoid permanent reduction of vital capacity, which occurs in man. Injections of alcohol were tried but discontinued for two reasons; they are not dependable and it is difficult to inject the right amount of alcohol without spilling a little. If any does escape, the amount of neuritis that can be caused is prohibitive. It has been found that by using a small ordinary forceps, clamping it tightly, and putting four bites of the forceps along the nerve that the paralysis can be made to last approximately four months.

Dr. Leo Eloesser, San Francisco: Under the influence of Dr. Alexander, within the last six months I have performed a thoracoplasty from the top down. It is too early to speak of results; however, there has been no immediate spread of the tuberculous process since the operation.

The results of Dr. Lemon's experiments are disappointing in a way. They show that the phrenic nerve operation is innocuous—that it does not seem to make much difference whether it is done or not. Corper of Denver has performed the same experiments on man that Dr. Lemon has performed on the dog. He inserted manometric needles with both sides of the chest in unilateral pneumothorax and showed that the human mediastinum is a yielding structure, and that within certain limits the two pressures rapidly approach the same level. So far as the technic of phrenic avulsion is concerned, it really does not make much difference, it seems to me, how the incision is made. The nerve is easy to recognize in that it is the only structure in the neck which runs from above downward toward the midline. All the other structures run downward and outward.

Dr. Edward A. Archibald, Montreal: I hoped that in this discussion of Dr. Lilienthal's paper there would be an expression of opinion from those who have had experience with the procedure as to the value of a two-stage thoracoplasty in the reversed order. Dr. Alexander proposed the method and Dr. Lilienthal has been using it, that is, first resecting the upper ribs after a phrenicotomy. I should like to know in particular what has been the experience of others as to the incidence of fresh tuberculous invasion of either lung following this procedure. The frequency with which this complication follows the standard Sauerbruch procedure of primary lower rib resection is now

known. One wishes to compare the two methods. It seems to me that the reversed procedure depends for its adoption on the demonstration of its capacity to lower the incidence of the spread of infection after operation. That, indeed, was the initial thought in Dr. Alexander's mind for reversing the procedure. On that the ultimate decision rests. I have reviewed my own figures in that respect carefully. I have also reviewed Brunner's statistics of 117 cases carefully, as Alexander did. I fail to find in the rest of the literature, except for an occasional half dozen cases or so, accurate case reports sufficiently lengthy to enable one to form an independent judgment. Consequently, this particular question is still undecided. I hesitate to reverse the order of procedure, because I find that in my own figures (in practically all cases thoracoplasty being performed from below upward and in two stages) the incidence of death from fresh tuberculous invasion is so low that I cannot understand how one could expect lower figures from the reversed procedure. Those figures are briefly that in ninety cases of posterior thoracoplasty, of which seventy-eight were total and twelve partial, the latter being performed because in most of them there was an artificial pneumothorax over the lower part of the lung, only three deaths occurred from the spread of tuberculosis. One of these was on the eighth day after a one-stage procedure, one on the sixth day after a simple phrenicotomy, and one in the fourth month. In the last, the responsibility of the operation might easily be doubted. The incidence of death from pneumonia following total posterior thoracoplasty is as low as 2.2 per cent.

The argument is sound theoretically; practically, I question it. Dr. Alexander speaks of the high mortality from the spread of tuberculosis as reported in the general literature, taking his figures chiefly from the German and Swiss reports. My own feeling is that in this country things are done differently. There are other factors to be considered besides the order of rib resection. For instance, in the older countries they do not understand anesthesia as we do. On the other hand, they have been using local anesthesia, freely, which predisposes to infection of the wound, and this predisposes to pneumonia. I counted forty-six infections of the wound in 117 cases as reported by Brunner, of which six were so severe as to cause death. Such fatalities do not occur in this country. In wound healing we can do better than that. The argument is complicated. Success does not depend on one factor; it depends on many factors. Until reports have been compiled of a sufficient number of operations by the reversed procedure, from above downward, showing an incidence of spread of tuberculosis as low as that of the ordinary procedure, I should hesitate to change the order. I still feel that Sauerbruch's warning as to aspiration pneumonia of the lower lobe when the upper ribs are resected first is justified.

Dr. Howard Lilienthal, New York: In answer to Dr. Welles, I would say that I did not go into the details of the operation. To palpate the anterior scalene muscle is the general practice. He says that it does not matter whether the scar is in one place or in another; but we have learned that in working about the neck, scars in the sagittal direction will tend to spread and produce keloids in many cases. These ugly scars also become indrawn. If the incision is made on the clavicle, the bone afterward supports the tissues so that there is not the slightest indrawing or the slightest dimple. This transverse scar is practically invisible at the end of about six months.

I use no skin sutures, but I employ metal clips wherever I can and take them out in four days. They leave no marks. If left in for more than four days, they may leave small suture points for a time.

In one of my left-sided cases of phrenic nerve avulsion, a small quantity of slightly opalescent fluid appeared during the operation which was thought to come from an injury to the thoracic duct. The avulsion was completed and the wound dressed; healing was uneventful. Knowing Costain's experience, I do not believe that ordinary slight injuries of this structure would counteract the advantages of the transverse clavicular incision. In any event, with blunt dissection the accident must be extremely rare.

One more thing about the phrenic nerve. As shown in my single picture of the immediate result of phrenic nerve avulsion, in a few days we had a high diaphragm on that side, equivalent to about 500 cc. of air. I considered that important. The fact that the dogs could work after the phrenic nerves had been operated on is not the point. We are not discussing that. We are discussing the alteration of the internal pneumatic conditions of the human chest, and they are certainly altered when there is such a considerable rise of diaphragm. I agree with Dr. Archibald that we ought to operate by graduated stages. One rib too much is a great deal worse than three ribs too few.

RATIONALE OF OPERATIONS HELPFUL IN PROMOTING RECOVERIES FROM PULMONARY TUBERCULOSIS

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All who escape untimely death from other causes are infected with tubercle bacilli. The majority are insusceptible and develop no recognized evidence of infection. The minority are of three grades of susceptibility. Those of least susceptibility recover spontaneously, often despite maltreatment. The moderately susceptible may recover if aided promptly and properly, or may arrest the progress of the disease spontaneously. The disease in the most susceptible may be arrested if treatment is favorable, or its progress may be only retarded.

The strength or weakness of resistance, defense and repair determines insusceptibility and the grades of susceptibility. Because they are the products of activities of cells, they are not static but dynamic, and are constantly fluctuating. Fluctuations are irregularly periodic and tend to take two courses. The more common course is downward. Through fatigue and exhaustion caused by unhygienic living, by intercurrent diseases and by age, people tend to forfeit more or less of their inherent stamina. Thus, insusceptibility may be replaced by susceptibility and the grades of susceptibility are intensified. Exceptionally, persons inherently of less competence live so wisely as to develop and to conserve the strength of their combatant cells. They become less susceptible or may even acquire insusceptibility.

The primary therapeutic aims are to prevent the insusceptible from becoming susceptible, to lessen degrees of susceptibility and to restrict exposures to infection. Secondary objectives are to employ without delay every means to aid in checking the progress of the disease, to enable each patient to approach as expeditiously and as closely as possible to the status conferring insusceptibility, and to maintain that highest level of improvement against the constant menace of recrudescence.

The specific obligations of treatment are to reduce offense, to augment defense and to conserve energy. The means to fulfil these obligations are the exclusive property of no school or specialty. They cannot be determined by human authority although they must be modified by experience. They are established by knowledge of the focal and disseminated destructive actions of tubercle bacilli, the local and systemic responses provoked and the existing offense-defense ratios in each

patient. Treatment approaches the height of effectiveness as it is adapted to conform with nature's methods and with the remaining potentiality of each patient; it should be inaugurated promptly so that its most valuable factor, that of prevention, can exert its greatest influence.

Tubercle bacilli, though low in virulence, are so high in viability that, once they enter, tissues of even insusceptible hosts sometimes not only survive decades of encapsulation, perhaps in calcified lesions, but retain a measure of pathogenicity. The insusceptible are able, because of the competence of the structures providing resistance, defense and repair, to inactivate the unexpelled parasites that have escaped destruction, and to encapsulate them so promptly in rapidly healing lesions that the resulting cicatrix is too small to impair function. Susceptibility results from incompetence of the structures affording resistance, defense and repair. In consequence, the tubercle bacilli are less promptly or less completely inactivated, if inactivated at all, and the involution of the disease is slower or its evolution is indicated by the increasing number, wider distribution and less favorable characteristics of local lesions.

Local lesions are the battlefields whereon the campaign waged by the host against the invading parasites is won or lost. There is little if any difference in the vulnerability of the normal lung structure and in lung structures affected by such conditions as passive congestion, cicatrices and emphysema. The outcome of the battles—in other words, the nature of the local lesions—is therefore determined almost exclusively by the quality and quantity of the blood delivered to them. The reinforcements delivered in the cellular and noncellular fractions of the blood enable insusceptible persons to control the invaders before they can establish themselves. The blood of susceptible persons contains inadequate combatant strength and the parasites are sufficiently virile to continue their offense, which is subsequently overcome by the least susceptible, checked by the moderately susceptible and somewhat retarded by the most susceptible hosts.

Accordingly, the attention of therapists should not be diverted in the least from local lesions, but should be enlarged to include recognition of the systemic sources of native and acquired combatant influences that are present in the blood. Thus it will be possible to develop methods to protect and to improve the competence of the structures producing resistance, defense and repair, which are prerequisite not only to recovery from every disease but to the continued existence of even the most robust.

It has been supposed that the pathogenesis and histogenesis of the tubercle were established. Medlar's [1] contributions show this to be

1. Medlar, E. M.: Am. J. Path. **2**:275-290 (July); 401 (Sept.) 1926.

erroneous and provide bases for a broader and more accurate conception of the entire process. This indicates that conceptions of the nature and sources of the constituents of the blood that combat the activities of tubercle bacilli in vivo, wofully limited as they are, are subject to revision. Nevertheless, enough facts are established to justify alterations and innovations in clinical methods. For example, it is known that the mother cells of the various blood corpuscles are irritated by the products of the activities of tubercle bacilli, particularly the erythroblasts, neutrophilic myelocytes, lymphoblasts and megakaryocytes. In consequence the blood picture is altered; some changes are beneficial, others detrimental. Hastened sedimentation rates have demonstrated untoward alterations in constituents of the plasma. Moreover, it is known that during intervals of improvement, and more particularly with continued progress toward recovery, the detrimental alterations in cells and in plasma tend to disappear.

Consideration of all established facts permits recognition of the objectives of treatment and simultaneously indicates feasible measures. The objectives are twofold: primarily, to promote permanent recovery from the disease by helping to increase and to sustain the competence of structures providing resistance, defense and repair, that is, all structures concerned in the production and delivery of blood, the entire circulatory apparatus; secondarily, to assist patients to combat lesions they are unable to control spontaneously.

The specific primary objectives are: (1) to improve the quality and maintain a proper volume of blood in circulation; (2) to increase the quantity of blood delivered to affected lungs and to minimize the expenditure of cardiac energy, and (3) to encourage effective hygienic living afterward.

Specific secondary objectives arise after the primary have failed. They are (1) alteration of intrathoracic tension by repeated costectomies so that after requisite spontaneous readjustment the lung will receive enough good blood to effect repair, and (2) eradication of such lesions as prevent recovery and cannot be repaired.

SPECIFIC PRIMARY OBJECTIVES

1. *Improvement of Quality and Maintenance of Volume of Blood.*—The sources of energy for tissues, including the hematopoietic, are ingesta and sunshine. So long as cells concerned in blood production are neither overfatigued by replacing blood lost through destruction or hemorrhage nor incapacitated by intoxication, they can recover spontaneously if their burdens are reduced. Rest, suitable diet and exposures to the direct action of sunshine, controlled according to the regimen of Rollier, suffice to reestablish their integrity and function. Greater incompetence

of hematopoietic cells, manifest in advanced anemia, in the distorted proportions of leukocytes, in diminished blood volume and in hastened sedimentation rates, is more surely and rapidly corrected with transfusions of unmodified blood, repeated until recovery is established. Expatients, particularly those who have recovered from more active forms of tuberculosis, are beneficial donors. The paraffined tube method is dependable.

Transfusions are not without danger even though the blood of donors is most carefully checked against that of recipients and incompatibility is eliminated. Thrombosis and embolism occur, although rarely. Too rapid introduction of blood will dilate and incapacitate the right side of the heart, which is often the determining factor in recovery. Preserved blood—or blood treated with available anticoagulants—adds little besides increased oxygen-carrying power and should be used exclusively for those exceptional patients who are not toxic but who are gravely anemic.

2. *Increased Amount of Blood Delivered with Least Cardiac Labor.*—According to Cloetta, the largest unit volume of blood is delivered to a unit volume of lung with the least cardiac effort when intrapleural negative pressures are reduced but not abolished. The vessels of a lung in this position of incomplete deflation offer the least peripheral resistance to the flow of blood. Peripheral intravascular resistance rises if the intrapleural pressures become atmospheric and the lung is in collapse, and is progressively much greater if the intrapleural pressures become increasingly positive and the lung is correspondingly compressed.[2] Experimental and clinical observations have demonstrated[3] that optimum reduction in intrapleural negative pressures follows inactivation and consequent upward displacement of the diaphragm. Under these conditions the deflated lung continues to function; there is neither hyphemia nor cellular deterioration from lack of use. The improved circulation resulting from the diminished peripheral intravascular resistance manifests itself in increased powers of pleuropulmonary resistance, defense and repair, which are probably at their best. Moreover, this is a defense response which occurs naturally in man and in animals in response to most acute and to some chronic irritations of the lung and pleura. It can be induced effectively by blocking the transmission of motor impulses through the phrenic nerve.

However, there is another noteworthy aspect. Individual competence, the ability to develop energy in excess of the amount required

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2. Yates, J. L.: Effects of Acute and Chronic Pneumothorax, Am. J. M. Sc. **165**:1 (Jan.) 1923.

3. Yates, J. L.: The Significance of Vital Capacity in Intrathoracic Therapy, Arch. Surg. **10**:477 (Jan.) 1925; The Significance of Vital Capacity in Intrathoracic Therapy, Arch. Surg. **12**:257 (Jan.) 1926.

to support inactive existence, depends on internal respiration, which is commensurate with vital capacity. Vital capacity is materially reduced by inactivation of the diaphragm; hence, the wisdom of inducing, whenever feasible, a temporary block of the phrenic nerve (phrenemphraxis) [4] rather than assuring a permanent paralysis of the diaphragm by exeresis or radical phrenicotomy.[5] Thus, persons who recover are not irreparably handicapped by the treatment they have received.

3. *Hygiene in After-Care.*—A little can be added to the established details of after-care. Periodic physical and roentgen-ray examinations of the lungs are insufficient. Determination of vital capacity and blood examinations, inclusive of differential counts and estimations of sedimentation rates, will occasionally reveal incipient recrudescences before they may otherwise be recognized, and usually indicate the seriousness of the problem. At such times a transfusion or two will accomplish much toward reestablishing a proper margin of safety, a greater preponderance of defense over offense. It is too seldom recognized that patients suffering from any form of tuberculosis are never cured. However complete the recovery or how protracted, those who have suffered from the disease will usually carry living organisms sufficiently pathogenic to renew their attack if the encapsulating lesions are disturbed and if the systemic sources of defense are weakened. Therefore, repeated reinfection is inevitable. The danger is illustrated by the frequency with which an

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4. Yates, J. L.: Operations as Adjuncts in the Treatment of Pulmonary Tuberculosis with Special Reference to Induced Diaphragmatic Palsy, Wisconsin M. J. **25**:273 (June) 1926.

5. The fibers that conduct sensory impulses from the tendinous portion of the diaphragm and motor impulses to the larger portion of its muscle are united in the phrenic nerve in about three out of five persons. The less typical distributions in the others are too numerous to describe or even to remember, were they all recorded. It suffices to know that instead of the main trunk two, perhaps three branches, may lie on the scalenus anticus muscle. Or there are accessory branches lying lateral or mesial to the muscle. Some may contain only sensory fibers. When attempting to cause a temporary block, and crushing is the most dependable method, it is necessary to locate all branches that transmit motor impulses. The presence of accessory branches will be suspected when the main trunk is unusually small. Then an effort is made to discover nerve twigs in the common and uncommon positions. Operations are performed on a fluoroscopy table. As nerves that bear motor fibers are crushed, the diaphragm contracts and then relaxes. Relaxation is complete, and a paradox appears when all the motor impulses are blocked. If the degree of immobilization obtained is insufficient, search for additional branches is continued until the desired result is obtained. Permanent paralysis is readily produced by exeresis unless the pleural adhesions are extraordinarily dense. Then the amount of traction required and the distress are prohibitive. It has sufficed to withdraw as much of the nerve as seems safe, cut distally as low as possible, and resect the proximal portion. One may not expect always to succeed in producing a complete paralysis. Exeresis rarely fails.

acute or subacute adenitis may reawaken a process of the lymph glands, or a lymphotoxic disease, notably influenza, is followed by renewed activity of a pulmonary affection. Retained health is purchased by constant vigilance.

SPECIFIC SECONDARY OBJECTIVES

1. *Alteration of Intrathoracic Tension.*—Thoracoplasty employed in treating pulmonary tuberculosis, like arthrodesis used in combating certain forms of joint tuberculosis, is still supposed by some to be indicated almost as soon as a diagnosis is made. Thoracoplasty, like arthrodesis, is only a means to aid healing of a local lesion, a means to be avoided, if possible, because of permanently impaired function. The function impaired by costectomy is external respiration, which is fundamental to life, and the extent of the impairment is measured by the reduction in vital capacity. Vital capacity is normal when mobility of parietes is unrestricted, intrapleural negative pressures are within usual limits and pulmonary elasticity is unimpaired, provided that proper amounts of good blood are delivered through the lungs under appropriate pressure. Pulmonary tuberculosis tends to reduce vital capacity by impairing both the breathing and the circulatory units. No more reliable indication of the efficacy of treatment need be sought than vital capacity, which should be reduced as little as possible during the acute phase of the disease and returned as near to normal as possible during convalescence.

If the object of thoracoplasty is to immobilize and to compress the lung, a consideration of the harmful effects of immobilization and compression which are not produced, even though costectomies are radical, might have a deterrent influence on its overenthusiastic advocates. Immobilization of any structure imposes deterioration on the cells affected, a progressive atrophy that tends toward necrosis and therefore reduces local resistance. It likewise produces hyphemia, which restricts the delivery of reinforcements needed to promote local defense and repair. Compression of the lung is not attainable even with complete thoracoplasty, but merely collapse, because the intrapleural negative pressures are replaced by atmospheric and not by positive pressure. But collapse restricts function, reduces the amount of blood delivered and increases the load on the right ventricle because intravascular resistance is raised.

The reasons for the good effects of thoracoplasty also establish its indications. Recovery from tuberculosis depends on healing of the local lesions. The healing in the insusceptible is so perfect that the resultant cicatrix may be undetectable, or so slight as to be negligible in its detriment to function. Destruction of lung substance is minimal. The repair of slightly more advanced lesions in which destruction of pulmonary tissue is less restricted produces a scar. If the cicatrices

are sufficiently numerous, the total effect is to cause fibrosis and impaired pulmonary elasticity and to alter intrathoracic tension. Other more advanced lesions associated with greater destruction of lung substance cannot heal because the contraction of the scar necessary to permit complete repair is prevented by the contrary parietal traction transmitted usually through pleuritic adhesions. Hence, if enough ribs, which have acted like the ridge pole of a tent and prevented contraction, are removed so as to permit of contraction, repair will be fostered if the blood supply is adequate.

Hence, the plan is to begin operative treatment not with thoracoplasty but with improving the quality of the blood and by inducing paralysis of the diaphragm. Alterations of intrathoracic tension thus induced may suffice to permit healing. If this fails to produce necessary improvement in a month or two, then ribs may be removed, a few at a time from below upward, or from above downward as seems best, with sufficient intervals between operations to determine when enough have been resected. Resections should be radical, i. e., extend from behind the angles forward to include some of the costal cartilages. This produces the greatest effect with each resection and helps to limit the number of ribs it is necessary to remove. The total incapacity from diminished external respiration may thus be limited to necessity; deformity is restricted and the more easily covered. More significant still, the operative mortality is virtually abolished. The operative burdens are limited, and the patients are well prepared to sustain them. They have already been provided with blood and have become accustomed to altered intrathoracic tension from the preceding paralysis of the diaphragm.

2. *Eradication of Irreparable Lesions Interfering with Recovery.*—A considerable number of patients are able to achieve healing of all but a few larger lesions, usually a cavity or a cluster of cavities, confined to one lobe, frequently the upper lobe. They are harassed by coughing, raise considerable sputum containing many organisms and are held in a state of chronic invalidism until their defense weakens. They succumb frequently to a pneumonic extension of the process. Lobectomy is indicated and is feasible if performed with a cautery as introduced by Graham. Several patients have been advised to accept the risks of this operation. None has accepted.

OBSERVATIONS

A series of 100 patients have been treated in conformity with the plan outlined in the foregoing during the last two years in cooperation with the staff at Muirdale Sanatorium for Tuberculosis, an institution conducted by Milwaukee County. The patients have not been coerced;

none has been subjected to any recognized danger that seemed unwarranted; neither has operative assistance been denied any patient whose complications were not of necessity fatal. The purpose has been to provide patients with opportunity for extension of life as well as recovery and not to accumulate statistics that might be imposing.

At first only those more seriously affected were subjected to operation. Some improved remarkably; then others consented; some asked to be given similar opportunities. Gradually, the less seriously sick are being subjected to phrenemphraxis. Records of physical, roentgen-ray, blood and sputum examinations and of vital capacity estimations have been kept, in addition to the usual history sheets. A summary of the more essential facts accumulated will be given. The particular purpose is to indicate the benefits obtainable from consecutive treatments based on the natural responses, with special reference to sunshine, transfusion and nerve blocking.

Means to Improve the Quality of the Blood.—The values of rest and diet are established. A more difficult matter is to secure cooks of proper competence, particularly when pay is restricted and employment is on a civil service basis. The management of few institutions unhampered by legal restrictions is seldom able to appreciate that money spent for high grade foodstuffs is largely wasted if preparation and service are mediocre.

The beneficence of sunshine for most patients, if it is not permitted to raise the metabolism too high, is not sufficiently appreciated. Facilities at Muirdale for living all the year in fresh air with opportunity for direct exposure to sunshine are still limited. The greater improvement of those who are in the pavilion provokes jealousy of many it cannot accommodate. Moreover, the anxiety of those accustomed to it to return when they have been transferred to other quarters after operation confirms the impression of its value. Other suitable quarters are to be supplied.

Transfusions have not been used as frequently as indicated. There has been difficulty in providing donors. Enough observations have been made to show that a patient suffering from advanced lesions, but with some reserve competence, can be given a necessary boost toward recovery with one transfusion whereas another whose local disease is less advanced but whose reserve powers have been dissipated will profit little from several transfusions. Extraordinary care must be used in selecting donors and in the methods employed. A serious reaction provoked by ill-suited blood or by methods that bruise it mechanically and alter the blood chemically may suffice to cause a fatality. Heart muscle, already fatigued and intoxicated though not irrecoverably impaired, is unable to withstand added stresses, particularly if they are added abruptly. Hence,

there is need for paraffined tubes and that they should be filled rapidly so that they may be emptied more deliberately and the transfusion terminated if signs of distress appear. Transfusions have not provoked hemorrhages in these patients. On the contrary, they replace serious losses of blood and may contribute to a cessation of dangerous bleeding.

Induced Paralysis of the Diaphragm and Phrenemphraxis.—Crushing the nerves conducting motor impulses to the diaphragm has been performed on eighty-five patients (seventy-eight in this series). The operative dangers are those incidental to infection, which are negligible. Those due to injuring other structures are avoidable. There is one postoperative danger. A measure of contralateral emphysema is produced as a rule by induced paralysis of the diaphragm. A superficial lesion of the supposedly sound or less involved lung can be ruptured and lead to a spontaneous pneumothorax which, if unrecognized and uncontrolled by aspiration, may lead to death. One such fatality has been noted; another was avoided by removing the air. Diagnosis of pneumothorax with a fluoroscope is easy and certain if the physical signs are confusing.

The dangers of subsequent hemorrhage are reduced. A few patients have raised blood streaked sputum some days after operation; one died from a single profuse hemorrhage from a bronchial artery on the third day before help could be given. Probably the destruction of the arterial wall was little influenced by the procedure. One patient in whom continued losses of pulmonary arterial blood threatened life did not bleed after phrenemphraxis. Another, lethally exsanguinated from repeated bronchial arterial hemorrhages received a blood transfusion and the nerve was blocked. He bled again that night; he was given another transfusion, and the bleeding ceased.

Exeresis.—The nerve has been withdrawn from the chests of eighteen patients. Twice withdrawal was incomplete and a phrenicotomy was performed. Twice the thoracic duct was torn and ligated without any noticeable handicap.

Effects on the Diaphragm Noted with the Fluoroscope.—Since experience has shown the importance of obtaining relatively complete relaxation, particularly that which leads to a paradox (the affected side rising during inspiration), and has taught how to find accessory branches, the majority of the operations performed have been satisfactorily effective. Exeresis failed to produce complete paralysis in only one patient. According to the amount of crushing employed, blocking can be made to last from two to five months. Degeneration of muscle is well advanced in six weeks, but apparently is recoverable up to six months. One patient thus far is known to have a permanent block when a temporary block was expected.

Exeresis has been performed sixteen times at first operation when a permanent block seemed indicated and twice after a temporary block proved insufficient.

Effects of Diaphragmatic Paralysis.—Immediately after induction there is often tachycardia for a day or two; coughing and expectoration are increased and a rise in temperature is frequent. Intrathoracic distress is usually reduced if it has been present. Then general improvement is the rule. The patients feel so much better that their testimony must be discounted. Coughing and expectoration decrease; there is diminished activity; the temperature is lower; the blood improves and vital capacity is higher. Improvement in the more fortunate is continuous. In others it is maintained until the diaphragm regains motion. In some the improvement lasts for a month or two and then they begin to retrograde. Improvement in the least fortunate is largely imaginary

Effects of Nerve Block on Ninety-Four Patients

	No. of Patients	Phrenemphraxis	Exeresis	Both Phrenemphraxis and Exeresis	Improved	Unimproved	Died
Group I: Far advanced bilateral; prognosis unfavorable	12	8	3	1	6	1	5†
Group II: Far advanced unilateral; prognosis unfavorable	22	9	8	0	16*	4	2
Group III: Moderately advanced, pleural adhesions; pneumothorax impossible	43	39	3	1	40	2	1
Group IV: Moderately advanced, no pleural adhesions; pneumothorax possible	14	14	0	0	12	1	1
Group V: Incipient but active	3	3	0	0	3	0	0

* Five of these patients were subjected to thoracoplasty. In two, one stage sufficed; in one, two stages, and in two, three stages were required.
† No death in the series resulted from operation.

and born of hope. None, so far as can be determined, has been injured except the patient who died from an unrecognized contralateral spontaneous pneumothorax, and this occurred before the present staff organization was effected.

The effects of nerve block on ninety-four patients observed long enough to be indicative are given in the accompanying table.

FIVE GROUPS OF PATIENTS

A review of the observations made has established errors, principally of omission, and suggests corrections. The number of our patients subjected to treatment is too small and the periods of observation too limited to justify more than tentative opinions. However, most of the patients were under observation for months, some for years, before special treatment was begun. The majority have been under continuous observation since. Their progress has been compared with that of other patients with similar conditions and, except for operations, given the same care. So, too, it has been possible to compare the effects of trans-

fusion without nerve block, of nerve block without transfusion, of nerve block and transfusion, and of costectomy with control observations on patients with similar conditions treated differently. Hence, there are sufficient grounds on which to base judgments.

Patients in group I were subjected to nerve block on the more affected side. Some of the operations were performed reluctantly because the patients requested them. A few of the patients improved unexpectedly. The question arises as to whether such patients as improved might have been served better if both sides had been paralyzed when activity persisted in the contralateral lung, or if thoracoplasty had been performed on the side first treated when the lesions in the other lung were inactive or became inactive.

The patients in group II are those accepted as needing immediate thoracoplasty. Nerve block obviated the need for operation in a number of them, and reduced the extent and risks of operation required in the others. Determination to avoid unwarranted radicalism has sometimes delayed operation too long. It is difficult to estimate the peak of improvement. When this has been reached, resections should be begun. Unfortunately, some patients, on account of the improvement, refuse to consent to further intervention until it is too late to obtain benefit from operation.

The treatment of patients in groups III and IV is even more perplexing. Hesitation to have a thoracoplasty performed, with its inevitable permanent disability and deformity, permits some to progress into the preceding categories. Cessation of progress toward recovery, if it can be recognized, is the indication to proceed so that the number of ribs necessary to resect can be restricted.

Patients in group V present the gravest problems. A goodly proportion will recover with the usual hygienic measures—some promptly, others slowly; in the remainder, the disease will progress. It is impossible as yet to recognize the differences in susceptibility at the onset or soon after. Few recover in less than three months. Future observations will determine whether it is advisable to employ phrenemphraxis almost as a routine. If it is true that it is virtually without danger, is harmless and certain to raise pleuropulmonary resistance, defense and repair, its employment is justified as prophylaxis against progress of the disease and also against retarded recovery.

It should be recognized that no method suggested here is considered the best treatment. Each in its place is regarded as a useful adjunct to other measures that together comprise the most favorable treatment for each patient. Advocacy of nerve blocking is based on the natural responses which are favorably influenced and justified by comparison of the progress of patients subjected to it with that of patients otherwise receiving identical treatment in the same environment.

THORACOPLASTY

Experience in performing costectomies on patients prepared by previous nerve block and perhaps transfusion supplementary to proper hygienic measures is limited. All told, eleven patients have been subjected to twenty-two resections, although only five are included in this series. The following points have been established: Nearly complete removal of each rib is more desirable than incomplete resection. If a few ribs are removed at one operation and intervals between operations are sufficient, the number of ribs finally resected, from three to eleven, is determined by individual requirements. Healing is excellent, and, except for accidents, which are largely avoidable, death almost never occurs. Failure to urge costectomy has been responsible for the failure of some patients to recover.

ERADICATION OF IRREPARABLE LESIONS

As stated in the foregoing, no operation that eradicates the lesions completely has been performed. The need of patients for the relief given only by operation makes it necessary to assume risks and to determine the safest procedures. To the present time, progessive cauterization as conceived and ably executed by Graham offers a probable solution.

SUMMARY

A proportion of patients seek help after they are beyond relief. Another proportion, those of the highest grade of susceptibility, are doomed. The balance will be given the best opportunity for recovery if measures are employed without delay to augment and conserve their powers of resistance, defense and repair by cooperating with nature.

The means to cooperate with natural processes are not defined by dogmas of therapeutists but by biology, not by erroneous human doctrines that fluctuate with a current popularity, but by immutable laws of nature. The object is to improve the quality of blood in circulation, to increase the quantity delivered to the local lesions and to conserve and develop the competence of each patient.

Available methods are in part nonoperative, in part operative. When employed in conjunction so as to provide each patient with opportunity for undelayed recovery without undue danger and distress, they constitute the most effective treatment.

The obligation is not to determine whether any given procedure is superior to any other, but what combinations of all methods, old and new, can be the most helpful to each patient.

The purpose of this article is to suggest the rationale and to illustrate the effectiveness of transfusions of blood and of induced paralysis of the diaphragm when used to supplement other methods, one of which should be suitable exposures to the direct action of sunshine.

ABSTRACT OF DISCUSSION

DR. EDWARD ARCHIBALD, Montreal: It is interesting to observe the particular application of Cloetta's experiment with regard to the circulation of blood through the lung in conditions of compression of the lung. The question arises as to just how far this is obtained by the temporary paralysis of the phrenic nerve. Without doubt, phrenicotomy is a definite influence, but I had not thought of it before. It never occurred to me that that would be sufficient to make Cloetta's experiments applicable, at any rate, in a large measure. Nevertheless, the idea is novel, and the explanation of the good effects of phrenicotomy is novel. I welcome the presentation of a group of patients treated in this fashion along physiologic and scientific lines. It seems to me that it gives us a new vista and puts us a decided step in advance. The effort to get away from operations is always welcome to me. I think anybody who operates much on tuberculous patients realizes that a major operation on them is always a risk. Obviously, this effort to postpone operation, to limit it to more carefully selected cases, is one that we should consider carefully. I imagine that possibly in the present wave of enthusiasm thoracoplasty is being done, not infrequently, in cases in which it is decidedly unsuitable. The only question I should like to ask Dr. Yates is with regard to the incipient but active cases I presume that these, which number only three, would lie in the class of apical tuberculosis. How far does a phrenicotomy on that side affect the activity at the apex? Of course, if it is a widespread activity through that lung, we could expect more from phrenicotomy. We know, at least it has been said, that phrenicotomy, even removed by the whole length of the thorax from the apical lesion, does affect the apical lesion in a sense. In any case, clinical improvement has followed phrenicotomy in more advanced lesions when the bulk of the lesion has been in the upper fourth of the lung. A patient with an early, active, incipient case hitherto has been given the ordinary hygienic treatment. Would these patients have improved in any case under ordinary hygienic conditions?

DR. A. V. S. LAMBERT, New York: This case should make us all think. It is a definite, conscientious effort to obviate the necessity for surgical intervention in cases in which the patients apparently are not doing well, and instead to use surgical measures on simple roentgen-ray examination. As Dr. Yates has stated, much more stress should be laid on the two elements of improving the quality and increasing the quantity of blood than on the elimination of the action of the phrenic nerve. To build up the resistance of these patients by transfusions is better than a simple division of the phrenic nerve. Many of us, I think, have been disappointed in the results from the simple division of the phrenic nerve; and there are no such statistics of good results from this procedure as there are from the use of transfusion. Therefore, the statistics Dr. Yates gives must be due to increasing the quantity and improving the quality of the blood. Since Dr. Yates had time only to sketch a description of transfusions, we have not been told how many, how often and what sort of blood examinations are necessary, how to determine when a transfusion should be made, and how much blood should be transfused. I am not so much interested in whether a phrenicotomy was or was not performed. That is the smallest part of the problem. Dr. Yates has done a piece of work better than any one else has done it. The two elements he has added are the quality and the quantity of blood.

DR. HOWARD LILIENTHAL, New York: I agree with everything that Dr Lambert has said except as to the phrenic nerve operation. I think that this operation is important. Any of you who have examined by fluoroscope patients with even tiny incipient apical lesions and have noted the striking fixation of the diaphragm on that side, must believe that the action of the diaphragm has something to

do with the progression of the disease: when the patient gets better, the diaphragm again begins to move. I think for that reason alone that nature seems to be pointing the way toward the treatment that Dr. Yates has given these patients, both by operating on the phrenic nerve and by the other forms of therapy that he has employed.

Dr. A. L. Lockwood, Toronto: I wanted to ask Dr. Yates just one question in regard to phrenicotomy in an entirely different matter from thoracic work. I think you all appreciate the fact that the mortality in ventral hernia is high in people over a certain weight. We made a study of people weighing more than an average of 165 pounds (74.8 Kg.), and I would be ashamed to tell you what we found the mortality to be. Last year it occurred to me to question whether it would be feasible or whether we could get sufficient change in intra-abdominal pressure following phrenicotomy to make it justifiable to inject the nerve before attempting repair of ventral hernias in obese patients. We would relieve the pressure just enough so that probably we could operate on a larger number of these patients with less risk. I am not absolutely convinced as to the value of living fascial sutures, although I have used them only eighteen times. I have followed a fair number and have not been absolutely convinced, because one of the patients I have in my care at the present time has had one repair. He has a tremendous abdomen. I do not know how to treat it. I should like to know Dr. Yates' opinion as to whether the injection of the nerve to give temporary relief on one side would relieve the intra-abdominal pressure sufficiently.

Dr. John L. Yates, Milwaukee: Abnormal spastic contractions of the diaphragm preceding flaccid relaxation and the forcing of the diaphragm into a high position occur in man and in animals when irritations of either visceral or parietal pleura are induced or develop spontaneously. Besides the clinical observations indicating the efficacy of improving the quality and increasing the quantity of blood delivered to lungs in helping patients to combat tuberculosis, other studies have shown that animals and man, whether suffering from acute or chronic pleuropulmonary diseases and wounds, could be similarly benefited. We are convinced that pleuropulmonary resistance, defense and repair are at their best when the lung is in a position near that of mean inflation and its excursions above and below this mean are restricted. We believe this position is assured by paralysis of the diaphragm and is manifested in natural defense responses.

It should be recognized that there is one unavoidable danger from phrenemphraxis. A certain amount of compensatory emphysema is produced in the contralateral lung. If there is a superficial lesion of this lung, it may rupture and produce a spontaneous pneumothorax which, if unrecognized and unrelieved by aspiration, can cause death. This accident, though rare, is noteworthy because it is easily recognized and remedied.

Dr. Archibald asked what effect is produced on the apex of the lung when the diaphragm is paralyzed. If the chest is free from adhesions, the reduction of intrapleural negative pressures affects the entire lung, and a rather homogenous incomplete deflation results. If there are adhesions about the basilar lobe sufficiently firm to prevent the diaphragm from being displaced upward, the total effect, especially on the apex, will be reduced or absent. This has been established clinically by the futility of employing diaphragmatic paralysis in combating lesions of the lower lobes, particularly in bronchiectasis.

Dr. Lambert is requested to refrain from spanking our pet child too hard. The quality of blood in circulation must be improved if patients are to realize full opportunities for recovery. This is basic to all therapy. It is scarcely less urgent to increase the quantity of blood delivered to local lesions, particularly

with lessened cardiac effort. These factors provide for repair of lesions and for conserving the latent energy of the right side of the heart, on which recovery so often depends.

It should be remembered in reading the records of Muirdale Sanatorium for Tuberculosis that these patients were given the best care the management of the institution provides and that operations are merely adjuncts to treatment. Moreover, the patients subjected to operation had been under observation for weeks, months, some for years, in the same environment. Their condition is recorded as improved only if all observations, including blood examinations, sedimentation rates, physical examinations, vital capacity determinations, roentgenograms and fluoroscopic readings, are confirmatory. Their progress is also compared with that of other patients similarly affected but not subjected to operation. The progress compares favorably, but there is not as yet enough evidence to warrant any more definite statement.

There is general misapprehension as to the value of exposure to direct sunshine as a help to patients in combating pulmonary tuberculosis. It should be recalled that ingesta and sunshine are the sources of energy. If patients are overexposed to sunshine, their metabolism is hastened, and they are injured because of the increased consumption of fuel to provide for energy production. They must be treated wisely and not too well. Dr. Kassowitz, who controls this work at Muirdale, has studied under Rollier, and his careful methods have been remarkably successful.

Dr. Lambert asked for indications for transfusion. They are reductions in erythroblasts and in hemoglobin, reductions in the actual number of lymphocytes, distortion of proportions and numbers of leukocytes, and particularly hastened sedimentation. All have noted that the blood conditions become less favorable as patients are losing ground and become more favorable as they improve. We have observed the other aspect: If the blood is improved by transfusions, the patients likewise improve if they have not lost their capacity to recuperate. There is a widespread belief that transfusions are of little value for patients suffering from pulmonary tuberculosis. The reasons are that citrated blood has been employed instead of unmodified blood and that transfusions have not been performed repeatedly and frequently.

Dr. Lilienthal was good enough to give our efforts commendation because methods cooperating with nature's responses were of necessity the most efficacious. If anything has been accomplished, it is attributable to attempts to imitate the natural reactions of man and divers animals which confer the greatest defense to pleuropulmonary structures.

Dr. Lockwood's question may be answered. Numerous roentgenograms shown today illustrated the high position of a paralyzed diaphragm. The high position is produced by the combined actions of intrapleural negative pressure and of intra-abdominal positive pressure on an atonic diaphragm. If the amount of intra-abdominal pressure were materially increased, as after the repair of an enormous ventral hernia, the greater upward displacement of the diaphragm could so alter intrathoracic pressures as to embarrass the heart, already somewhat incompetent. One would judge that the increase in intra-abdominal capacity consequent on induced paralysis of the diaphragm would be too little to be effective, and the dangers might be considered prohibitive. Rather might it be wiser to increase the size of the belly cavity by causing relaxation of the abdominal walls induced by incisions, as advocated by Crile.

ACCESSORY THORACOPLASTIS OPERATION FOR COLLAPSE OF LARGE TUBERCULOUS CAVITIES

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One of the most discouraging features of the surgical treatment of pulmonary tuberculosis is the failure of apical cavities to collapse completely following paravertebral thoracoplasty. In a fairly large proportion of the cases in which there is a cavity of large size, on examining the postoperative roentgenograms, one finds that the cavity is reduced to one half or one third or even one fourth of its former dimensions. It is a natural tendency to regard this as a good result, and the surgeon is inclined to consider the case as satisfactorily completed and to hope that in the following six months the remaining space will close in by natural processes of fibrosis and shrinking of the whole lung. Too often, however, this further collapse does not occur, the patient continues to raise several ounces of sputum every day, and the cavity is found to be just as large as it appeared in the roentgenogram made immediately after operation, or even slightly larger. The next procedure to undertake is a difficult question to decide. To operate again in the back and attempt to remove the plates of bone that have reformed from the periosteum left at the previous operations and to take out further sections of ribs under the scapula is a procedure the difficulties of which can be appreciated only by one who has attempted it. When these difficulties are overcome, the resulting compression may be disappointing and make no alteration in the size of the cavity. Anterior apicolysis is probably the operation of choice, as by this method the apex of the lung with its parietal pleura can be peeled downward, forcibly compressing the cavity. One of the various types of plug must then be employed to fill in the top of the chest, obliterating dead space and keeping the lung from reexpanding. The fat transplants of Tuffier and the paraffin or gauze packs used by the Germans have not attained popularity in this country. The pedicled muscle flaps proposed by Archibald seemed at first to offer a satisfactory solution to the problem. Unfortunately, however, in thin persons the muscle transplant is not sufficiently large. Even when most of the pectoralis major and all of the minor is used, and even in those cases in which the flap appears adequate, there are later shrinkage and contraction which diminish the apical compression. The operative shock following apicolysis is fully as great or greater than that produced by posterior thoracoplasty; there is always the risk of breaking into the cavity during the difficult separation of the pleura from the ribs, and on the whole the operation is far from satisfactory.

Fig. 1.—Chest of W. J. M. before thoracoplasty, showing enormous cavity involving practically the whole upper lobe on the right; fluid level from unraised sputum in the cavity. Phrenicotomy had already been performed, which accounts for the height of the right side of the diaphragm.

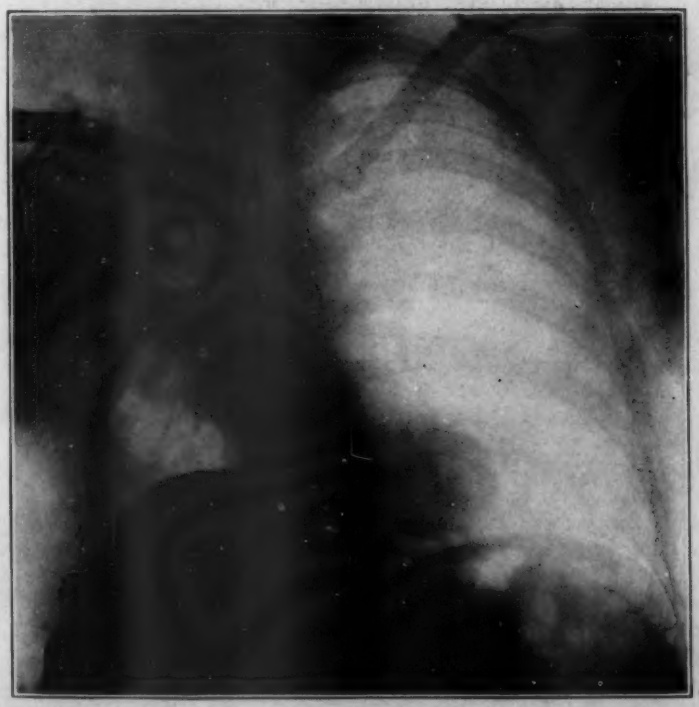

Fig. 2.—W. J. M. immediately after a complete posterior thoracoplasty; the cavity is reduced to a small triangular space.

It is to avoid the necessity of these undesirable measures that the following procedure is proposed. The operation is not presented as a new or an original one, but is being drawn to the attention of thoracic surgeons as a valuable adjunct to the routine posterior thoracoplasties, to be used promptly as an additional stage in the operation in the cases in which incomplete collapse is secured. It consists in the removal of further sections of the upper ribs through an axillary incision.

Fig. 3.—W. J. M. three weeks after figure 2 was taken, showing an increase in the size of the cavity. This was accompanied by an increase in sputum.

PROCEDURE

The patient lies on the back with the arm extended above the head. An incision is made in the anterior axillary line, starting at the tendinous portion of the pectoralis major and extending downward to the sixth or seventh rib. Skin and subcutaneous fat are cut through and as no muscles, large vessels or nerves are encountered, there is little bleeding, and the ribs are promptly exposed in a line posterior to the origins of the pectorals and anterior to the digitations of the serratus magnus. Beginning with the fourth rib, stripping with a periosteal elevator is at once begun, and the rib is bared forward under the pectoral to the cartilage, and backward under the serratus attachment all the way to the cut end left by the posterior thoracoplasty. The rib is removed in its entire length and the process is repeated with the third, fifth, sixth and probably the seventh, depending on the location and size of the cavity. The second rib is somewhat more

difficult of approach, and it may not be possible to remove its entire remaining length. A good sized piece, however, 2 inches (5 cm.) or more long, can be excised. It is not necessary to cut the first rib if it has already been divided in the posterior operation. Following the subperiosteal removal of the ribs, the lung will be seen to sink in freely with each inspiration, as in the paravertebral operations. The wound is closed with one subcutaneous layer of catgut and the ordinary skin stitches. There are no muscle layers to suture. A rubber drain is brought out through a small stab wound in the posterior axillary line, as it gives much better drainage there than if inserted in the main incision. A large pad

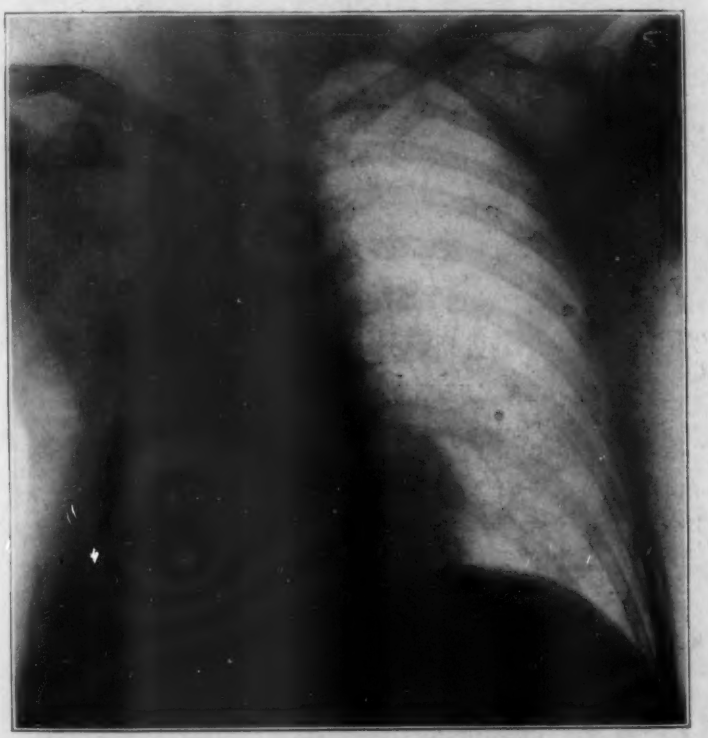

Fig. 4.—W. J. M. after accessory operation in axilla, showing much more complete compression of the whole right lung and obliteration of the cavity.

of dressing is applied and held tightly in place by adhesive strips running from sternum to spine. The use of the new elastic adhesive plaster (elastikon) is greatly to be recommended as it gives a steady pressure on the wound.

COMMENT

There is surprisingly little shock following the operation; much less than with paravertebral thoracoplasty or anterior apicolysis. My patients have been able to leave the hospital within a week after operation.

The result in cases in which the operation is performed soon after posterior thoracoplasty, before the periosteum left in the back has had

a chance to form new solid bone, has been most encouraging. One successful case is shown in figures 1 to 4. In other cases, in which the axillary operation was not attempted for six months or a year after thoracoplasty, the resulting compression was much less and the benefit derived correspondingly slight.

It is my intention to use this procedure in the future in those cases in which inadequate collapse is secured as soon after the thoracoplasty as the patient is in condition for a further operation. I feel sure that I shall have a smaller number of discouraged patients coming back several months later asking for further relief.

UNCOMPLICATED UNILATERAL BRONCHIECTASIS

LATE RESULTS OF EXTRAPLEURAL THORACOPLASTY

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By uncomplicated bronchiectasis is meant the characteristic changes of that disease in a portion of the bronchial tree without parenchymal abscess formation or pneumonitis as determined by the roentgenogram. A more or less uniform shadow may be due to a thickened pleura only, but until recently there has been no means of excluding abscess or pneumonitis on a clouded roentgenogram. The clinical picture of chronic paroxysmal cough with an abundance of purulent sputum, clubbed fingers and more or less general debility is characteristic of uncomplicated bronchiectasis. Recurrent attacks of fever with an associated rapid loss of weight and strength and increased amount of foul sputum is typical of bronchiectasis with involvement of the surrounding lung tissue, the exacerbations of symptoms marking an extension of the disease process. In doubtful cases, however, in my experience the roentgenogram has been the final criterion of uncomplicated bronchiectasis (figs. 1, 2 and 3).

Extensive bilateral bronchiectasis is obviously not amenable to surgical treatment. The differentiation between unilateral and bilateral involvement has been difficult and uncertain. It has rested largely on the roentgenogram and the presence or absence of certain physical conditions. The roentgenograms following the injection of iodized oil, 40 per cent, will probably not only enable us to determine the distribution but may also enable us to recognize types of the disease hitherto indeterminate. In the cases reported here this method was not yet available. In my case 12, the pneumothorax therapeutic test demonstrated the unilateral involvement, although the evidence from bronchoscopy pointed to bilateral involvement. Other cases were excluded as bilateral by the pneumothorax therapeutic test.

Graded extrapleural thoracoplasty implies a collapse of the wall of the chest in several operative stages. The simplest and most effective method for securing a maximum collapse is the paravertebral resection of the upper eleven ribs. The resulting longitudinal drop of the whole wall of the chest is the most important factor in this massive collapse. In pulmonary tuberculosis, in which the apex usually is first and chiefly involved, its collapse is absolutely essential. In bronchiectasis, on the other hand, the lower portion of the lung is almost always the only part diseased. In order to secure complete collapse of the base without

collapsing the normal upper portion of the lung, a complete resection of the whole length of the lower ribs is necessary, and resection of the fourth and often of the third rib must be included in order to prevent their suspending effect on the lower part of the wall of the chest.

Experience has shown that the operation cannot be performed safely in one stage in the presence of a large amount of sputum on account of the danger of pus retention and pneumonia, and because of the shock produced by so extensive an operation in a debilitated patient. A

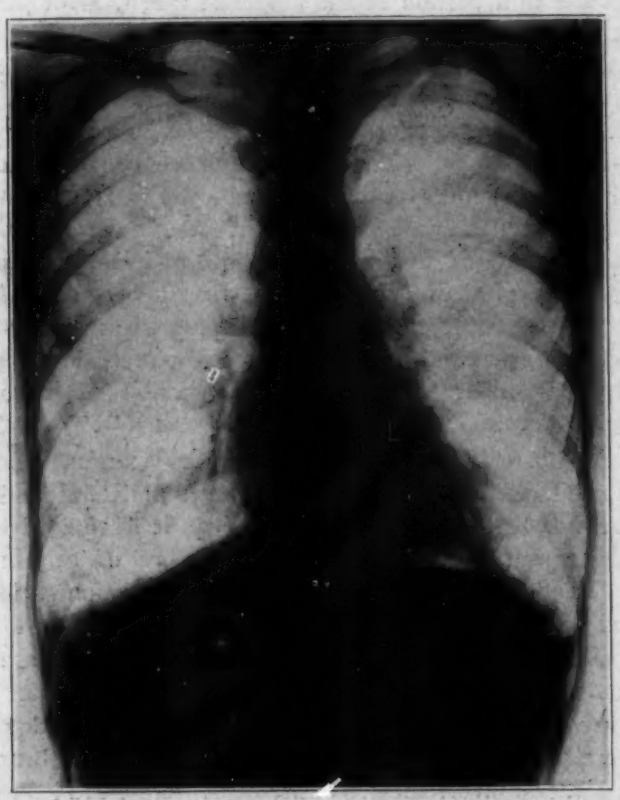

Fig. 1.—A girl, aged 11 years, who had coughed and raised large amounts of sputum since an attack of pneumonia three years before; there is an absence of any abnormal lung markings, except a few linear streaks covered by the cardiac shadow.

several stage operation is necessary, graded to the patient's particular condition.

In 1923 I read a paper before this association reviewing the literature on the results of various surgical methods in the treatment of bronchiectasis, and included the case reports of seven patients on whom I had performed a graded extrapleural thoracoplasty without mortality and

with encouraging results in all cases. On the basis of this comparative study of operative mortality on the one hand and of relief of symptoms on the other, following the various methods of treatment, I expressed the opinion that this method would seem to commend itself to further consideration. I found that unfavorable opinions regarding thoracoplasty were based largely on a priori consideration, on a one stage operation with high operative mortality or on the failure to get results

Fig. 2.—Same patient as shown in figure 1 taken after the injection of iodized oil, showing diffuse cylindrical bronchiectasis of both lower lobes.

after an incomplete collapse. It seems probable also that some of the unfavorable results were in cases of combined abscess and bronchiectasis.

One of the questions frequently raised in relation to extrapleural thoracoplasty in bronchiectasis is as to the permanence of any immediate improvement obtained. It may be of interest, therefore, to record the further progress in the seven cases already reported, and the results in a later series of seven others observed from two to three years after

operation. Short abstracts of the former and more detailed reports of the latter follow:

CASES PREVIOUSLY REPORTED

CASE 1.—A boy, aged 19, had a postempyema bronchiectasis of about two years' duration. The sputum averaged from 240 to 500 cc. in twenty-four hours. The third to the eleventh ribs were excised in five stages. He gained weight and strength immediately after operation, and the sputum dropped to 30 cc. in twenty-

Fig. 3.—Simple cylindrical bronchiectasis of the right middle lobe.

four hours. During three years following the operation, there were intervals when he was practically symptom-free, but for the most part he continued to raise from 60 to 150 cc. of sputum in twenty-four hours.

CASE 2.—A man, aged 28, had had symptoms of bronchiectasis from infancy without known etiology. The sputum averaged from 500 to 1,000 cc. in twenty-four hours. The fourth to the tenth ribs were excised in three stages. The sputum decreased to from 30 to 90 cc. soon after the operation, and has averaged 60 cc. in twenty-four hours during nearly six years afterward. The patient is in the best of health, and is steadily employed at hard manual labor.

CASE 3.—A girl, aged 12, had a postinfluenza bronchiectasis of three years' duration. The sputum was foul, averaging 500 cc. in twenty-four hours. The fifth to the eleventh ribs were excised in four stages. Immediately after operation the sputum decreased to from 15 to 30 cc. in twenty-four hours, and the patient was no longer kept awake at night by cough. She gained 15 pounds (6.8 Kg.) in weight in two months. During the last four years she has remained consistently symptom-free, has gained 40 pounds (18.1 Kg.) in weight, has finished high school and has the appearance of good health.

CASE 4.—A woman, aged 32, had a posttonsillectomy bronchiectasis. The sputum varied from 120 to 500 cc. in twenty-four hours. The third to the eleventh

Fig. 4.—Bronchiectasis of the left lower lobe after the injection of iodized oil.

ribs were excised in five stages. A marked general improvement followed. She has had occasional attacks of pain in the chest since with an increase in the cough and sputum, but these have always been much less than before operation.

CASE 5.—In a boy, aged 14, the onset of cough and sputum followed an appendectomy, five years before thoracoplasty. The sputum was variable in amount, reaching 300 cc. in twenty-four hours. The third to the eleventh ribs were excised in five stages. There was marked immediate general improvement and decrease in the amount of sputum. Nine months after operation abscesses began to form in the soft tissues of the chest wall, the pus from which showed

actinomycosis. He died of general asthenia a month later. (This was probably a case of actinomycotic infection of the lung following the onset of pulmonary symptoms after appendectomy.)

CASE 6.—A girl, aged 18, had bronchiectasis of nine years' duration following pneumonia. The sputum averaged from 360 to 480 cc. in twenty-four hours. The thoracoplasty was not completed on account of the pneumonia after the fourth stage. The cough and the sputum were not affected. A year later, the median segments of the sixth to the tenth ribs were removed. The sputum then diminished to about half that before thoracoplasty and the general condition was improved. Two and a half years after this, a partial cautery lobectomy was performed. Since this operation the sputum has averaged about 60 cc. in twenty-four hours. The patient has gained 15 pounds (6.8 Kg.) in weight and is in good general condition.

CASE 7.—A frail, anemic woman, aged 22, had had frequent hemoptysis in early childhood. She had raised purulent sputum which had increased in amount since she was 10 years of age until it was 240 cc. in twenty-four hours. Following a seven stage excision of the second to the eleventh ribs, the cough and sputum almost disappeared. At intervals she had no symptoms and the sputum never amounted to more than 30 cc. in a day. She gained in weight from 91 to 115 pounds (41.3 to 52.1 Kg.). This improvement has persisted, except for a few remissions, when the sputum increased to 60 cc. in a day. She has done all her housework unassisted.

CASE 8.—*History.*—A man, aged 19, a student, presented himself at the Mayo Clinic, Jan. 10, 1923, complaining of cough with purulent sputum. When 8 months old he was said to have "swallowed" a head of wheat which almost strangled him. He had had bronchopneumonia shortly afterward, for which he had been treated at the Mayo Clinic. He had had a cough since, with a gradually increasing amount of sputum, at times blood streaked. Following tonsillectomy nine months before admission, the amount of sputum increased to from 240 to 300 cc. in twenty-four hours.

Examination.—The patient was in a good general condition. He had several carious teeth. The cervical and axillary glands were enlarged. There were loud bubbling râles at the right base. The blood pressure was 120 systolic, 80 diastolic; the hemoglobin content was 80 per cent; leukocytes totaled 9,200. No tuberculosis bacilli were found in the sputum. The urine was normal. The roentgenogram showed an extensive bronchiectasis at the right lower lobe and an old tuberculous process at the left upper lobe.

Operation and Course.—An extrapleural collapse of the right side of the thorax was effected by a seven stage operation, with removal of practically the whole length of the fourth to the eleventh ribs, inclusive. The posterior segments were first resected through a paravertebral incision in three stages, and the nerve trunks were injected close to the transverse process of the corresponding vertebra with 95 per cent alcohol solution. The anterior segments were next resected from below upward in two stages through a parasternal incision, the lower lateral segments through an incision parallel to and over the eighth rib, and the upper lateral segments through a midaxillary incision. The average interval between the stages was two weeks.

The amount of sputum gradually decreased during the course of the collapse operations to from 60 to 90 cc. in twenty-four hours. He was then discharged in good general condition, May 11.

He returned for observation, June 29. Examination showed a good collapse of the right lung, but Litten's sign was still present on the right. A right phrenic resection was performed on the third day, following which he was discharged from the hospital.

On August 1, he returned for examination. The cough was no longer paroxysmal as before. The sputum averaged 60 cc. in a day. Fluoroscopic examination showed immobility of the diaphragm in a relaxed position. The general condition was excellent.

On September 6, roentgen-ray examination showed a remarkable amount of rib regeneration in a position of partial expansion of the pleural cavity. The

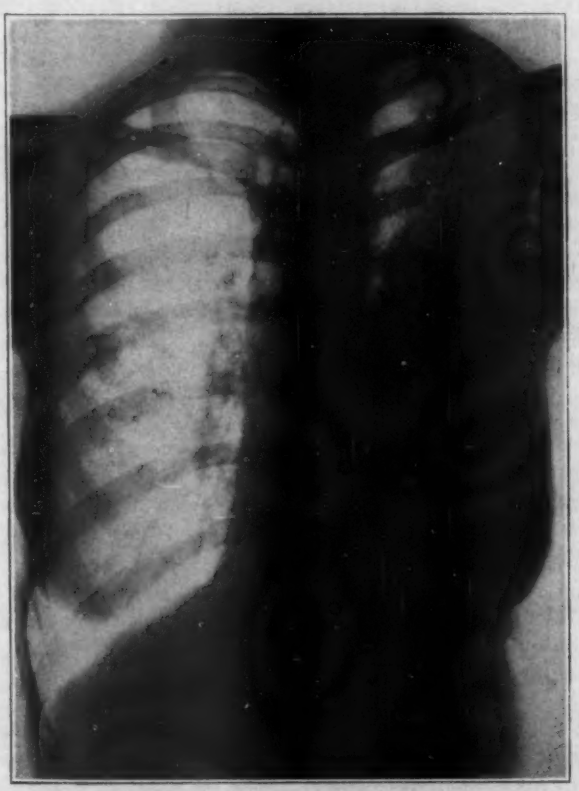

Fig. 5.—Appearance of same patient as shown in figure 4, after the injection of iodized oil after a three-stage extrapleural thoracoplasty in which the full length of the third to the eleventh ribs inclusive were resected.

regenerated segments were excised through the old lateral incisions. There was an immediate collapse of the underlying lung. At the time of his discharge, he was gaining weight and the sputum averaged from 60 to 90 cc. The sputum has persisted at about this amount during the three years that have elapsed. The general condition has been good.

CASE 9.—*History.*—A girl, aged 20 years, came to the Mayo Clinic, May 23, 1923, complaining of purulent sputum and of weakness of four years' duration. The onset of symptoms dated from an attack of pneumonia in the spring of

1918. She had been in bed for one month and had remained weak and coughed all summer, but had raised no sputum. In the autumn, following an attack of influenza, she began to raise green, foul smelling sputum, which gradually increased to 120 cc. in twenty-four hours. In May, 1922, she was sent to a tuberculosis sanatorium, where she remained for five months. A diagnosis of pulmonary abscess was made, and pneumothorax collapse was instituted and continued until about a month before she came to the clinic.

Examination.—The weight was about normal, and the general condition seemed good. The fingers were clubbed, and the nails were watch crystal in shape. The left side of the chest lagged on respiration and the characteristic evidence of pneumothorax collapse was present, except toward the base. Roentgen-ray examination showed the left lung collapsed from above to about the nipple line laterally. The hemoglobin content was 90 per cent; the white blood cells totaled 13,500. The urine showed a small amount of albumin; the sputum was negative for tuberculosis bacilli. A diagnosis of bronchiectasis was made.

Treatment.—A more complete pneumothorax collapse of the lung was attempted, 2,000 cc. of air being instilled in five sittings during a period of twenty days. At the last sitting, the water pressure registered between 0 and plus 4 after 200 cc. had been injected.

The sputum decreased to about 15 cc. in twenty-four hours during two weeks of observation. Another attempt at pneumothorax was therefore made, but the pressure became plus 4 after 300 cc. of air was instilled, and the roenten ray showed the lung to be adherent at the diaphragm, preventing further collapse.

A graded thoracoplasty was then performed in six stages, the whole length of the fourth to the eleventh ribs being resected. She complained little of pain following the operations and had no complications. The sputum averaged about 60 cc. at the time of her discharge from the hospital. A little more than a year later, she reported that she was in good general health and had gained considerably in weight, but was raising from 30 to 120 cc. of sputum in twenty-four hours. Later, she was reported to have died of acute poisoning.

Case 10.—*History.*—A laboring man, aged 25, came to the Mayo Clinic, July 12, 1923, because of weakness and hemoptysis. In 1917, following a severe attack of influenza, he had had three attacks of hemoptysis, raising about a pint (473 cc.) of blood at each attack. Since then he had had a chronic cough, raising about 60 cc. of blood tinged sputum in twenty-four hours. In December, 1922, he had had another profuse hemorrhage and had had several since then, averaging in amount from 250 to 500 cc. He had been in bed since the last one, March 15, 1923.

Examination.—The patient appeared in fairly good general condition. The left side of the chest lagged on inspiration. The percussion note at the left base was impaired, with diminished fremitus, and fine crepitant râles were heard on inspiration. The hemoglobin content was 72 per cent, and the leukocyte count 7,000; the Kolmer test was negative. The sputum showed no tuberculosis bacilli. Urinalysis was negative. Roentgen-ray examination of the chest showed no abnormality. Fluoroscopic examination revealed no motion of the left side of the diaphragm. A diagnosis of unilateral bronchiectasis of the hemorrhagic type was made.

Treatment.—A six stage thoracoplasty was performed during a period of nine weeks, the whole length of the third to the eleventh ribs, inclusive, being resected. There were no postoperative complications and little pain.

During the next two years, the patient had three hemorrhages at intervals and the sputum, which fluctuated from 30 to 90 cc. in twenty-four hours, was occa-

sionally blood streaked. He reported that he was 8 pounds (3.6 Kg.) underweight, but that he was doing light work.

CASE 11.—*History.*—A man, aged 27, a bookkeeper, presented himself at the clinic, July 23, 1923, complaining of a chronic cough with a large amount of purulent sputum. In January, 1918, he had had influenza, which confined him to bed for two or three days, and he had not been well since. About six months

Fig. 6.—Same patient as shown in figures 4 and 5, showing paravertebral hooked incision extending below and anteriorly in the course of the ninth rib. The three stages of the operation were performed through the same incision.

after the attack of influenza, he had begun to raise large amounts of purulent sputum. At first he had had a feeling of being "clogged" in the left side of the chest under the sternum, which had caused him to cough. He would then lean forward and bring up from 120 to 960 cc. of yellowish green pus. After a time, the attacks of coughing had become more frequent, until recently he had had

from four to five attacks a day. In 1920, he had been treated at home for five months for "tuberculosis." The next year a change of climate had brought about some improvement in the general condition only. In the spring of 1922, he had begun to have fever and pleuritic pains, and had been in bed for four weeks. He had had two similar attacks since, each accompanied by marked weakness and loss of weight.

Examination.—The patient was undernourished and anemic; the breath was foul and the fingers were clubbed. The entire left side of the chest lagged on respiration. There was decreased fremitus at the left base posteriorly and sibilant and bubbling râles, but no dulness to percussion or other abnormality. Roentgen-ray examination showed infiltration of the lower left lobe. The sputum showed no tuberculosis bacilli. Urinalysis was negative; the hemoglobin content was 79 per cent; the white blood cells totaled 8,200, and the Kolmer test was negative. The diagnosis was bronchiectasis of the left base.

Treatment.—An extrapleural thoracoplasty was performed in six stages at intervals of about one week, the whole length of the third to the eleventh ribs, inclusive, being resected. The convalescence was entirely uneventful. The vital capacity on admission was 3,900 cc. At the time of discharge, it was 2,650 cc. The hemoglobin was 55 per cent, and the white blood cells totaled 13,000. He gained in weight and strength. The sputum averaged from 180 to 240 cc. in twenty-four hours, and has persisted at about this amount since.

CASE 12.—*History.*—A married woman, aged 28, came to the Mayo Clinic, Aug. 9, 1923, complaining of cough with sputum and weakness. The cough was said to have dated from birth, and the patient could not remember when she did not have it. It was present all the year around, but was worse in hot weather and had been gradually increasing, especially in the last three years. The sputum was always thick, purulent, and of foul taste and odor, averaging from 120 to 240 cc. in twenty-four hours. She never had had any hemorrhages. Bronchoscopy showed some pus coming from the left lower bronchus, but most of it came from the right.

Examination.—The patient was somewhat emaciated. The breath sounds were tubular in character, and there were a few râles at the right base. Roentgen-ray examination of the chest showed bronchiectasis at the right base and some changes on the left. A roentgenogram of the right antrum of Highmore and of the right frontal sinus was clouded. The systolic blood pressure was 110, the diastolic 68. Urinalysis showed a small amount of albumin and some pus cells. The hemoglobin content was 77 per cent; the white blood cells totaled 7,800, and the sputum was negative for tuberculosis and fusiform bacilli. The Kolmer test was negative. The diagnosis was bronchiestasis of the right base (congenital?).

Treatment.—Because of the question of bilateral involvement, a pneumothorax collapse was deemed advisable as a therapeutic test. The lung was completely collapsed by nine instillations of filtered air, each of from 300 to 400 cc., and in all totaling 3,400 cc. The intrapleural pressure at the initial instillation was from 5 to 7 cc. negative pressure. At the last refills, it fluctuated about zero. The roentgenogram showed complete collapse of the left lung.

During the next two weeks, the sputum was practically nil, and the patient stated that she felt better than at any time before in all her life. The only symptom was dyspnea on exertion.

Because this therapeutic test seemed to show a unilateral involvement and one amenable to collapse therapy, a thoracoplasty was advised. A seven stage thoracoplasty was performed, from the second to the eleventh ribs, inclusive, being

resected during a period of seven weeks. The patient had practically no pain following any of the resections, and was usually up in a wheel chair the day following operation. Following the fourth stage, a pleural effusion suddenly developed, and 1,200 cc. of fluid was aspirated; 1,800 cc. of more sterile effusion was aspirated at two later sittings. The severe dyspnea was relieved by these aspirations. The patient was dismissed from the hospital one week after the last stage operation. At this time, she coughed only occasionally, raising perhaps a teaspoonful of viscid material. The weight was 97 pounds (44 Kg.). The vital capacity was 3,737. Neurologic examination showed anesthesia of the distribution of the spinal nerves which had been injected on the side on which the operation was performed.

A few months after returning home, she had pneumonia in the uncollapsed lung, but recovered. The general condition since has been good. She has done all her own housework since the operation, and spends a great deal of time in the summer caring for her garden. About a year after the operation the patient wrote, "I still cough occasionally and raise some sputum, but nothing to speak of, and the sputum I raise now is altogether different from the sputum I used to raise. I wish you could see how well I use my right arm."

CASE 13.—*History.*—A woman, aged 20, a teacher, came to the Mayo Clinic, Nov. 20, 1923, because of cough with foul sputum, fever and pleural pain. The past history was of no significance. She had had a tonsillectomy at the age of 13, and the left turbinate had been removed and the left antrum drained three months before coming to the clinic.

At the age of 15 months, she had had a bronchopneumonia. She had had a high fever and had been extremely ill for ten days. The mother stated that from that time she had had a chronic cough, with purulent sputum, and that she would wheeze whenever she lay down. Following tonsillectomy, she had improved somewhat. The cough was caused especially by stooping. The sputum was purulent and greenish and there was about 250 cc. in twenty-four hours. The amount gradually increased. She stated that she always had from two-tenths to 1 degree of fever. Occasionally, she had twitchy pains in the left side. She complained also of shortness of breath on exertion and of early fatigue. She had had two acute attacks of pain in the right lower quadrant of the abdomen and much soreness in that region since.

Examination.—The patient was a frail looking girl, weighing 110 pounds (49.9 Kg.). The fingers were clubbed. At the left base of the chest from about 5 cm. below the angle of the scapula, there was dulness to percussion and absent breath sounds. Above this level the sounds were bronchovesicular, with increased vocal resonance. When the patient bent over, she raised 120 cc. of thick green, foul-smelling pus. The base was then resonant, and the breath sounds were bronchial in character. Roentgenograms showed slight bronchial thickening at the left base. There was tenderness to palpation over McBurney's point. Urinalysis was negative. The hemoglobin content was 75 per cent; the leukocyte count totaled 17,800, and the Wassermann reaction was negative. The sputum showed no tuberculosis or fusiform bacilli or spirillae. The diagnosis was left bronchiectasis.

Treatment.—Two stages of a graded thoracoplasty were performed at intervals of one week, 10 cm. of the fourth to the eleventh ribs posteriorly being resected. Following the second stage operation, a pleural effusion developed. One liter of blood stained fluid was aspirated on December 12; on the next day, 2 liters of turbid fluid, and on the next day, half a liter of semipurulent fluid were withdrawn. The fourth day the fluid was definitely purulent and catheter drainage and irrigation were instituted, first, sodium chloride solution and then surgical

solution of chlorinated soda (Dakin's solution) being used. The cavity had a capacity of 1,500 cc. at this time, and the sputum averaged about 450 cc. in twenty-four hours. Ten days after drainage was instituted, a toxic arthritis with edema developed over the knees and the ankles, but this gradually subsided. A month after the onset of the empyema, the cavity measured 270 cc. in capacity. On January 25, the patient developed an acute attack of appendicitis, and an appendectomy was performed. The convalescence following this operation was uneventful.

On April 15, the empyema was 15 cc. in capacity. The sputum varied from 30 to 75 cc. in twenty-four hours, and the patient was in a good general condition, weighing 5 pounds (2.3 Kg.) more than on admission. A plastic operation was then performed, and the patient was dismissed on May 2. At this time, the sputum averaged from 60 to 90 cc. in twenty-four hours. She was advised to return in two or three months for the completion of the thoracoplasty.

On June 11, 1924, the patient wrote that she still raised from 60 to 75 cc., and that she had gained 7 pounds (3.2 Kg.) in weight. In June, 1925, she came for inspection. She had taught a country school all year, walking a mile to and from the school in all kinds of weather and building her own fires. She appeared well, and physical examination showed no involvement on the opposite side. In June, 1926, the patient wrote that she had finished another year of teaching. The sputum was from 45 to 60 cc. in a day; the weight averaged from 102 to 104 pounds (46.3 to 47.2 Kg.)

CASE 14.—*History.*—A married woman, aged 46, came to the Mayo Clinic, Oct. 30, 1923, because of a chronic cough with purulent sputum. She had a dorsolumbar scoliosis of pronounced grade which had begun when she was 11 years of age. Except for this she had been entirely well, had had three children and had always worked hard.

Eight years before admission she had had a postpneumonic empyema, which drained through a bronchus periodically for five years. A rib resection had then been done for drainage of the empyema cavity. She continued to cough and raise an average of about 250 cc. of foul, purulent sputum after the empyema cavity healed.

Examination.—The patient was a weak, poorly nourished woman, weighing 88 pounds (39.9 Kg.), 22 pounds (10 Kg.) under her normal weight. There was a marked scoliosis and kyphosis of the dorsal and lumbar spine, the concavity being toward the left. There were no abnormal physical conditions in the right side of the chest. Roentgen-ray examination showed the characteristic picture of a diffuse bronchiectasis process on the left without evidence of pleural thickening or increased density of lung parenchyma. The urine showed a moderate amount of albumin and the sediment a few pus cells. The hemoglobin content was 75 per cent; the white blood cells totaled 15,300, and the Wassermann reaction was negative. The diagnosis was bronchiectasis on the left.

Treatment.—A three stage thoracoplasty was performed under combined regional and ethylene analgesia, the whole length of the ninth, tenth and eleventh ribs being resected at the first stage, the sixth, seventh and eighth at the second stage, and the second, third, fourth and fifth at the third stage. It was necessary to resect the second rib in order to allow the lower angle of the scapula to lie flat against the collapsed chest wall. The ribs were extremely deformed, a sharp angle replacing the normal longitudinal curve, and the ribs were greatly thickened and triangular in cross section. The external surface was about 1 cm. in width, the upper and lower surfaces from 2.5 to 3 cm. in width.

There were no postoperative complications. She suffered little pain after the operation except in the shoulder. The cough and sputum disappeared entirely following the last operation, and the general condition improved markedly. The deformity of the chest was much reduced. The patient has reported at intervals that she has had no cough or sputum, has gained in weight and is doing all her own housework and helping her husband with outside farm work. Her only complaint has been of shortness of breath in attempting to do heavy work.

SUMMARY OF CASES

Of the fourteen patients on whom a graded extrapleural thoracoplasty was performed, six were males and eight females. Five were under 20, the youngest being 12 years of age; seven were between 20 and 30, one was 32 and one, 46. In four the symptoms dated from infancy. The duration of symptoms in the others ranged from two to nine years. In one of the four cases that dated from infancy, there was a history of a foreign body and in one of an attack of pneumonia. In the other two, there was no known etiology. Possibly these were cases of congenital bronchiectasis. In the others, the symptoms followed influenza in three, pneumonia in three, empyema in two, appendectomy in one and tonsillectomy in one. The right base was involved in seven, the left base in seven. The maximum amount of sputum was under 200 cc. in one, between 200 and 500 cc. in ten, and between 500 and 1,000 cc. in two. In case 10, repeated profuse hemoptysis was the presenting symptom, between the attacks of which he had practically no cough or sputum.

There was a history of occasional attacks of slight fever with pleuritic pains in four, but none had had high fever, chills, loss of weight or other symptoms characteristic of abscess or pneumonia.

The roentgenogram in all cases except two showed the characteristic indefinitely outlined markings of bronchiectasis and nothing more. In one (case 10) the roentgenogram showed no abnormality, and in one (case 6) there was some uniform faint clouding characteristic of thickened pleura.

The thoracoplasty was performed in stages under combined regional and gas-oxygen analgesia with alcohol injection of the nerve trunks close to the spine to minimize the pain after operation. The whole length of the lower ribs, usually from the third to the eleventh, inclusive, was resected in multiple stages, the number of stages depending on the condition of the patient. In one (case 6) the thoracoplasty was not completed on account of a pneumonia following the fourth stage operation, and in one (case 13) on account of empyema after the second stage operation. A pleurisy with sterile effusion developed in two cases without interfering with the operative treatment. There were no other complications. There was no fatality after operation.

There was a marked decrease in cough and sputum, gain in weight, and general improvement in all cases during the first four weeks following operation. In four, the sputum decreased from 200 to 500 cc. to 15 cc. or less in twenty-four hours; in three, from 500 to 1,000 cc., from 240 to 300 cc. and from 250 to 300 cc., respectively, to from 60 to 90 cc. in twenty-four hours.

All these patients were followed for three years after operation and all except two (cases 1 and 4) have been followed to date, or to within a few months of the present time. Three have died, one (case 10) from a fatal hemoptysis. This, it will be recalled, was his outstanding symptom throughout. One (case 5) died of actinomycosis of the chest wall ten months after operation. It seems probable that this was a case of actinomycotic bronchiectasis. The third (case 9) died from acute poisoning. She was in fairly good condition during the two years that elapsed between the operation and her death, but continued to raise about 60 cc. of sputum in twenty-four hours. Six have remained markedly improved in general condition and the sputum has been reduced to an average of from 60 to 90 cc. in twenty-four hours. Two of these six patients have occasional exacerbations of symptoms when the sputum reaches 25 per cent of that before operation. Five may be said to be practically cured from the standpoint of symptoms and general health. One of these five (case 2) raises consistently from 60 to 90 cc. of sputum (500 to 1,000 cc. before operation), but that is his only symptom. He works steadily and is in the best of health. Another (case 7) has an exacerbation of cough with sputum three or four times a year, incident to a "cold," when she raises about 30 cc. of sputum. The other three have no cough and sputum or other symptoms and are living normal active lives.

COMMENT

Extrapleural thoracoplasty for bronchiectasis has been generally condemned—in most instances on the basis of a few cases—as a dangerous and ineffective operation. Performed in a single stage and under general anesthesia, it is, indeed, a dangerous operation. If, however, it is performed in stages, the number of them depending on the condition of the patient, and under local or combined anesthesia, the operative mortality on the contrary should be low. In my experience, it has so far been nil. The operation has been called ineffective because a collapse of the diseased lung, it is stated, is impossible and because the pathologic process is not affected. In reply to these statements, it may be stated that a review of roentgenograms taken after the collapse is completed demonstrates in each instance, in my experience, as complete a collapse as is obtained in favorable cases of pulmonary tuberculosis, after paravertebral thoracoplasty, and that although the diseased bronchi

are not eradicated the operation has proved effective to the extent of markedly relieving cough and sputum in all cases, approximating a cure in many.

For those patients whose symptoms persist to any extent, a cautery lobectomy or a resection of the diseased lobe can be performed with relative ease of exposure and without the risk of tension pneumothorax from a retraction of the bronchial stump or from empyema. Sauerbruch reports lobectomy in six cases following thoracoplasty without mortality.

The operation of graded thoracoplasty, in my opinion, should be limited to undoubted cases of bronchiectasis. In cases in which the bronchiectasis is complicated by multiple or multilocular pulmonary abscess, the operation, in my experience, is relatively ineffective and the postoperative mortality is high. In a few cases in which abscess was recognized or suspected, improvement approximating a cure has resulted, but the operative mortality was more than 40 per cent.

The postmortem examination in all cases showed multiple or multilocular abscess in addition to the bronchiectasis. In my experience, the unclouded roentgenogram has been the only sure means of recognizing the borderline type of such cases.

Much renewed interest in the study and treatment of bronchiectasis will result from the introduction of iodized oil for its diagnosis. This method should be of the greatest value in making possible early diagnosis, in differentiating other pathologic conditions, and in the differentiation of bilateral involvement. In early unilateral, uncomplicated cases, pulmonary compression, pneumothorax collapse, phrenico-exeresis and in cases of insufficient relief by the simpler procedures, graded extrapleural thoracoplasty merits first consideration. For those cases in which there is not sufficient relief by these methods, pulmonary resection should be a relatively safe and effective operation.

ABSTRACT OF DISCUSSION

Dr. Howard Lilienthal, New York: I wish to say that on theoretical grounds I was one of those who doubted the wisdom of thoracoplasty, but I have been convinced and now am on Dr. Hedblom's side. Dr. Packard of Saranac Lake referred to me a woman, aged 33, who had been coughing since she was 2 years old. In spite of that fact, however, the opposite lung was in good condition. She had been treated for tuberculosis for a long time. This seems to be one of those cases in which there are cavities as well as bronchiectatic conditions. These cavities were probably not active abscesses, but partly healed cavities whose walls were secreting less than the bronchiectasis below. The patient was not able to do any work. She was upraising large quantities of sputum; in fact, she did not know of a time when she did not spit and cough. I operated on her in two stages because she was in splendid condition, and she stood the ordeal well. Excellent collapse was secured. After the second stage, the patient stopped coughing. I have never seen anything like it. It was as if a faucet had been

turned off. Later there was a slight recurrence during the few weeks in the hospital, but finally all symptoms ceased.

Another patient, a boy, had been coughing and spitting foul pus for twelve years, ever since he had had whooping cough. He is now 18 years old. I had him treated bronchoscopically in the hope that Dr. Yankauer might help him by lavage. Immediately after the procedure there was a terrific reaction, with a temperature of 104 + F. and a weak pulse. I thought that he would die. Still I determined to try again. I did not want to operate on him if it could be avoided. He was thin and a poor risk. The bronchoscope was used again, with the same result; then he said that he would have no more bronchoscopy. I should have said so, too, although I am an ardent advocate of bronchoscopy. I performed this operation in two stages. There was almost as prompt and good a result as in the case of the young woman. He coughs a little in the morning, raising less than 30 cc. of sputum which is not foul, although the discharge had been extremely putrid before. He is working. I have had other cases in which I have attempted this operation, some of them many years ago, and it was on the result of these early attempts that I expressed disapproval of the method. The procedures were unsuccessful before the posterior method came into use. I have had one patient, but her case was one of those in which Dr. Hedblom warns that the operation should not be performed. A girl, aged 9 years, on whom everything else had been tried unsuccessfully had a unilateral bronchiectasis and abscesses. I had opened the abscesses by pneumonotomy and had pushed the pleura from the wall of the chest, hoping to get a certain amount of collapse without performing a complete thoracoplasty. It did no good. The girl improved for a time; but she came back frequently for treatment for exacerbations. I then performed a thoracoplasty, but it did not cure her. Dr. Hedblom probably would have predicted that it would not. Then I tried the cautery pneumonectomy; she died of hemorrhage a few days afterward. She had one hemorrhage that I was able to stop because I happened to be there and plugged the wound. Then at 4 a. m. a few days later, when I was not in the hospital, there was another hemorrhage and she quickly died. I have seen many hemorrhages in cases of suppurations of the lungs, and I would emphasize again that this is one of the reasons for operating in these cases. I am glad that Dr. Hedblom evidently thinks as I do.

Dr. Willy Meyer, New York: It has been interesting to hear the late results of thoracoplasty in bronchiectasis. I recall the time, some fifteen years ago, when I began this work, when I had two cases in which I saw signs of brain involvement, abscess with suppurative meningitis. The patients died. Death occurred from this cause in about 25 per cent of the suppurative lung cases. That seems rather high. Although the procedure in the cases of Dr. Hedblom and Dr. Lilienthal was excellent the branch of the pulmonary artery might first be ligated and then a thoracoplasty performed, because the tying of this artery also produces the carnification of the lung. Of course, bronchiectasis is principally a disease of the bronchial system; yet carnification of the lung tissue helps. I have used the operation in three cases; the three patients recovered. When the adherent lobes of the lung are separated, it is possible to infect the pleural cavity.

I like to recall my experience with a patient in whom there was improvement after I had tied this branch of the pulmonary artery. He was not willing to have the additional thoracoplasty done, and went to Georgia because of the higher altitude. He reported from time to time. I repeat that nothing else was done but the tying of the respective branch of the pulmonary artery. He was in a poor condition, unable to attend to business, but today he is completely cured. Perhaps the combination of surgical intervention with the proper altitude is desirable in these cases as it is in the treatment of tuberculous patients after extra-

pleural thoracoplasty. In advanced bronchiectasis this conservative type of operation has been performed with excellent results by a number of the members of this association. It is advisable to try it, particularly as it often is an introductory measure to the cautery excision or the resection of the respective lobes of the lung.

Dr. Stuart W. Harrington, Rochester, Minn.: My experience with surgical pleural collapse of the lung by removing the bony framework has been of only two years' duration so that I cannot report late results. My results have been practically the same as those of Dr. Hedblom. My experience has been with seventeen cases, in which there has been one death from bronchiectatic abscess or abscess associated with bronchiectasis. The indications for surgical collapse should be established definitely. I have been cautious in the use of iodized oil in cases in which I planned surgical collapse, probably unjustified because of the possible retention of the oil. All patients are examined bronchoscopically to determine as nearly as possible whether the disease is confined to one lung and how extensive it is in that lung. I have usually performed the surgical collapse in three or four stages; recently I have been performing a much more extensive operation than formerly. I am now taking up the cartilage of the rib, leaving the cartilaginous angle from the sixth to the eleventh. Few patients have recurrences in which collapse was not complete in the lower lobe most extensively diseased. Hemorrhage is one of the chief indications for surgical collapse. The patient who died following the first stages was a poor surgical risk. She was sent away for three or four months. She returned with a recurrence of symptoms, having severe hemorrhage. I believe that death was caused by a cerebral hemorrhage due to pneumonia, caused by the retention of secretions. Results in the remaining sixteen cases have been satisfactory. I have a follow-up method for the patients. Every six months they fill out a questionnaire as to progress. Recent cases show results which may not be accurate because the time the cases have been followed has been too short. Of twenty-two patients whose cases I have followed for more than a year, all are well, and there have been no deaths in the group. Possibly some of the cases were of the minor abscess type, but practically all the patients have gone back to their usual life, and have been satisfied with the results. I have had two patients who have had slight bleeding following surgical collapse, but not of any serious degree. I agree with Dr. Hedblom in his views on the subject.

SURGICAL TREATMENT OF INTRATHORACIC TUMORS AND TUMORS OF THE CHEST WALL*

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It is difficult to distinguish the various forms of tumor of the thorax and chest wall clinically. It is first important to differentiate benign and malignant tumors. In many instances, the clinical history and physical manifestations of the tumor suggest the type of growth, but histologic examination of the tissue must usually precede accurate diagnosis.

The malignant tumors may be considered in two groups: those that primarily involve the structure of the thorax and chest wall, and those that secondarily involve these structures either by continuity or by metastasis from a primary growth elsewhere in the body. In the latter group, carcinoma of the breast is probably the most common primary lesion. Carcinoma of the thyroid not uncommonly invades the anterior mediastinum and manubrium. However, the primary lesion may arise in any part of the body.

In this article, I have not included the metastatic malignant tumors or intrathoracic goiter. I shall review the cases of malignant and benign primary tumor of the thorax and chest wall in which I have operated during the last two years. There are sixteen cases in the series: eleven of them were cases of malignant tumor, two of which were intrathoracic; five were cases of benign tumor, none of which could be definitely differentiated clinically from malignant tumors.

The benign tumor is usually hard, fixed and smooth, and the malignant hard, fixed and irregular in outline. The regional lymph nodes were not enlarged in any case, not even in the cases of extensive malignant disease.

The chief complaint was tumor in eight of the cases of malignant tumor and in one case of benign tumor. It was pain in three cases of malignant tumor and in four cases of benign tumor (table 1). In three cases the patient thought the tumor was in the mammary tissue.

There is little of diagnostic value in the age, sex or site of the tumor (table 2). The more malignant tumors were in the youngest patients. The right side of the thorax was more commonly affected than the left. The benign cases occurred only in females, and in two instances the tumor was thought to be in the mammary tissue.

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* From the Division of Surgery, Mayo Clinic.

The rapidity and duration of growth seems to be the most distinctive characteristic in this series. The benign tumors were practically all of slow growth. The malignant tumors were uniformly of more rapid growth (table 3). It was noted in three of the malignant cases that a small tumor followed an injury which occurred forty, twelve and six years previous to examination, respectively, and that the growth, after being dormant for many years, suddenly increased in size.

TABLE 1.—*Tumor of the Chest Wall*

Chief Complaint	Malignant	Benign
Tumor of chest wall on right	4	1
Tumor of chest wall on left	3	..
Tumor and pain of chest wall on right	1	2
Tumor of breast	1	2
Pain in right shoulder and arm	1	..
Pain in left shoulder	1	..
Total	11	5

TABLE 2.—*Age and Sex of Patient and Side Affected*

	Average Age, Years	Female	Male	Right Side of Chest	Left Side of Chest
Malignant	32+	6	5	7	4
Benign	35+	5	..	4	1
Total		11	5	11	5

TABLE 3.—*Symptoms and Course*

	Growth of Tumor			History										
	Slow	Rapid	Dormant; Growth Later	Pain	Pain Before Tumor	No Pain	Injury	No Injury	Loss of Weight	No Loss of Weight	Respiratory Symptoms	No Respiratory Symptoms	Average Duration, Months	Cases
Malignant	4	3	4	4	2	7	4	7	6	5	5	6	4	11
Benign	4	1	..	2	..	3	1	4	2	3	1	4	7	5

Pain was not a constant or differentiating symptom of malignant and benign tumor, but when present with a rapidly growing tumor usually indicated a severe grade of malignancy. Pain was noted before the presence of the tumor in two of the malignant cases.

A history of previous injury at the site of the tumor was noted in four of the malignant cases and in one benign case. In three of the malignant cases the injury occurred years before and in one the tumor immediately followed the injury. This suggests the possibility of trauma as an etiologic factor in some of the malignant cases. There was no history of injury in seven cases, but it is possible that some previous

injury may have been overlooked or forgotten. Loss of weight and undue dyspnea were not of diagnostic importance. Some degree of dyspnea was present in five cases. The two intrathoracic malignant tumors caused dyspnea from pressure. In the other three cases the dyspnea seemed to be closely associated with pain in the tumor. The average duration of the malignant tumors was four months, and of the benign tumors seven months. Loss of weight was slight except in three cases of extensive, rapidly growing tumor.

In table 4 the cases have been grouped according to the type of operation performed and the result obtained. The result has not been tabulated if the operation had been performed less than six months previously. The technic and extent of the operative procedure must of necessity vary to meet the indications in each case. In order to

TABLE 4.—*Intrathoracic and Chest Wall Malignant Tumors*

Case	Age, Years	Pathologic Diagnosis	Intrathoracic Tumor	Tumor of Chest Wall	Radical Operation	Palliative Operation	Pleural Cavity Opened	Recurrence	Present Condition Good	Months Since Operation	Subsequent Death	Months After Operation
1	31	Fibromyxosarcoma	+*	..	+	..	+	+	+	8	..	..
								6 months				
2	18	Osteofibrosarcoma	+	..	+	..	+	—†	+	17	..	..
					Two-stage							
3	13	Osteogenic sarcoma	..	+	..	+	..	+	..	..	+	2
4	15	Malignant endothelioma	..	+	+	..	+	+	..	..	+	5
5	3	Osteogenic sarcoma	..	+	..	+	..	+	..	..	+	5
6	58	Chrondrosarcoma	..	+	+	..	..	—	+	12	..	..
7	54	Chrondrosarcoma	..	+	+	..	..	—	+	18	..	..
8	42	Lymphosarcoma	..	+	+	..	..	—	+	14	..	..
9	45	Fibrosarcoma	..	+	+	..	..	—	+	11	..	..
10	46	Lymphosarcoma (myeloma type)	..	+	+	..	..	—	+	15	..	..
11	29	Fibromyxosarcoma	..	+	..	+	+	Recent operation				

* Positive. † Negative.

simplify the tabulation the term "radical operation" has been used when the complete removal of the tumor was attempted and "palliative operation" when only a portion of the tumor was removed. A more complete account of the operative procedure is given with each case history.

Ethylene under positive pressure was the anesthetic in all operations. Radiotherapy was instituted either at the time of operation or soon afterward in all cases of malignant tumor. The operative procedure or results in the benign cases is not tabulated, as an exploratory operation, with removal of tissue for diagnosis, was performed in all five cases without complication or operative mortality.

There were two cases of intrathoracic tumor; the tumor was radically removed by a one-stage operation in one case, and by a two-stage operation in the other. The pleural cavity was opened during the operation in both cases without serious complication at the time of

operation. Pleural effusion and collapse of the lung on that side followed the operation in both cases. The pleural effusion was aspirated and absorption of the fluid followed with ultimate complete reexpansion of the lung. There was a small recurrent tumor in one case after six months, and it was removed. There has been no recurrence in the other case, and the patient is in good condition now, seventeen months after operation.

Radical operation was performed in six cases of tumor of the chest wall, with recurrence and death in one case five months after operation. In five cases there was no recurrence, and the patients are in good condition. The shortest length of time since operation is eleven months. Palliative operation was performed in two cases, in both of which death has subsequently occurred. Operative death did not occur. Three children under 15 years of age have died since operation.

The cases of malignant tumor were all classified pathologically as sarcoma, with one exception, which was endothelioma. The grading of the malignancy in the report of cases follows Broders' classification.

In the five benign cases the diagnosis was: atrophy of bone, tuberculous osteomyelitis, exostosis of bone, achondrosis of cartilage and areas of necrosis of cartilage.

SUMMARY OF CASES

In eleven of the sixteen cases of tumor of the chest, either intrathoracic or parietal, reported here, the tumor was malignant, and in five benign; in two cases of malignant tumor, it was intrathoracic.

The clinical differentiation of early malignant and benign tumors of the chest wall is difficult. When the diagnosis is doubtful, exploratory thoracotomy is indicated.

Early radical extirpation of malignant tumors, followed by radiotherapy instituted at the time of operation or immediately after operation, has given the best results. In cases of extensive disease, partial removal of the tumor, followed by the use of radium, did not seem to prolong the life of the patient or relieve the symptoms. Intrathoracic tumors at the apex of the lung may be exposed by cutting the clavicle. Large intrathoracic tumors of the lateral wall of the thorax may be removed by a two-stage operation, the first stage being directed at walling off the general pleural cavity by the formation of adhesions between the visceral and parietal pleura around the tumor.

Ethylene gas is a satisfactory type of anesthetic, and should be used with a positive pressure apparatus as the pleural cavity may be opened during any operation.

In six of the cases of malignant tumor, there has been no recurrence, and the patients have been well for from eleven to eighteen months after radical removal of the tumor. In one case of intrathoracic tumor, a

small recurrent tumor was removed after six months. In three cases, death followed recurrence within six months after operation; all of these were cases of extensive malignant disease in children. Operative death did not occur.

REPORT OF CASES

CASE 1.—A woman, aged 31, was admitted to the Mayo Clinic, Feb. 3, 1926, with pain in the right arm and shoulder, which had commenced twenty-four years before and had been constant and severe for six months before admission. Since the age of 7 she had had occasional attacks of dull, aching pain in the

Fig. 1.—Dilatation of superficial veins of neck and upper part of chest; Horner's eye syndrome from pressure on right cervical sympathetic nerve.

right elbow and ulnar side of the right forearm, lasting intermittently from a few minutes to several days. The attacks were thought to be trival, and were treated as rheumatism. One year before admission, the attacks had become more frequent and severe and of longer duration. Six months later, the pain had started as usual but had not subsided and had persisted constantly and with increasing severity after that time, so that opiates were required for relief. At the time of admission, the patient was taking from six to eight capsules in twenty-four hours. During the last two months before admission, the pain was severe, especially in the right shoulder, and was accompanied by pain, tingling and numbness down the ulnar side of the forearm and into the fifth, fourth

and ulnar side of the third finger of the right hand. The right arm was never swollen, and the patient said she thought that the arm had become slightly smaller during the last year. She had lost 5 pounds (2.3 Kg.) in weight during the year. She had been subject to migraine headaches for many years. There were no respiratory symptoms other than undue dyspnea on exertion. Four years before admission, a general examination had been undertaken because of suspected anemia. The abnormal physical signs in the upper part of the right lung prompted roentgenographic investigation, and a tumor was found at the apex of the right lung which extended to the level of the second rib. The finding of

Fig. 2.—Circumscribed tumor of upper part of right lung, with partial destruction of the first and second ribs.

the tumor was accidental, and there was no association made between the attacks of pain described above and the presence of the tumor until three and one-half years later, when the pain became constant and severe. Intensive roentgen-ray treatment was instituted without relief of the symptoms or any appreciable decrease in the size of the tumor.

The patient was moderately developed and nourished, weighing 100 pounds (45.4 Kg.). The pupils were unequal, the right contracted, and there was ptosis of the right eyelid (Horner's eye syndrome). The superficial veins in the right side of the neck and upper part of the chest were moderately dilated. The right hand was smaller than the left (the forearm 2 cm. smaller), sensation was

impaired, and there was numbness, 1+. The systolic blood pressure was 90 and the diastolic 78, practically the same in both arms. Raising the right arm caused diminution in the volume of the pulse and pain in the right hand. Dulness to percussion was found over the upper part of the right lung, with wheezing, bronchial breathing and increased vocal resonance and whispered sounds. The urine and blood were normal (fig. 1).

Roentgen-ray examination revealed a large circumscribed tumor in the right apex, extending to the third rib anteriorly and into the apex above the clavicle more anteriorly than posteriorly, with destruction of a portion of the first and second ribs and displacement of the trachea to the left (fig. 2).

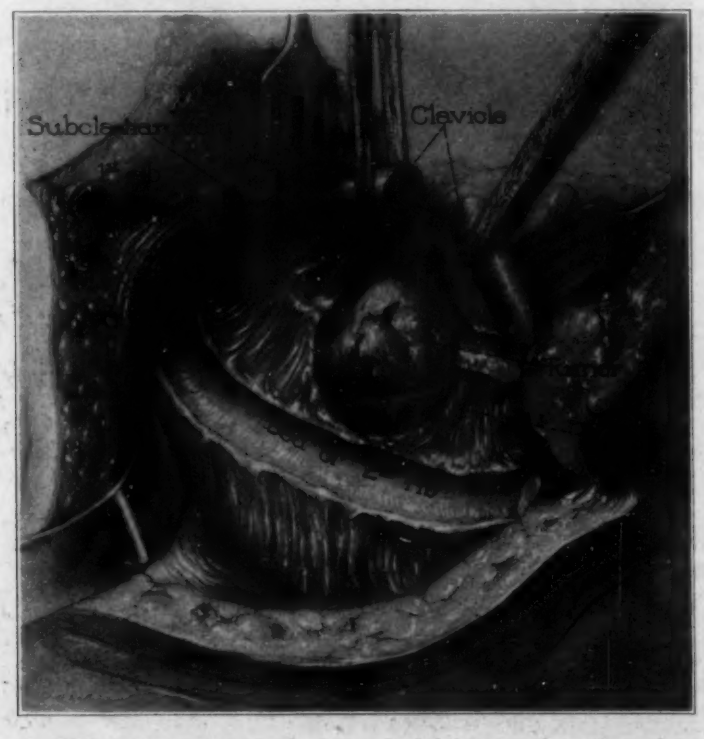

Fig. 3.—Fibromyxosarcoma of apex of right lung (intrathoracic); tumor exposed by resecting first and second ribs and cutting the clavicle.

Because the tumor was known to have been present for four years, and had probably existed for a much longer period, it was considered clinically as primarily benign, possibly fibroma, neurofibroma or dermoid cyst, but because of the marked increase of symptoms during the six months preceding admission the possibility of malignant degeneration was suggested. The clinical diagnosis was benign tumor, possibly with malignant degeneration, which involved the upper lobe and apex of the right lung in close proximity to the trachea, and secondary pressure neuritis on the brachial plexus (ulnar) and on the cervical sympathetic nerve, producing Horner's syndrome. Exploration was advised.

I performed the operation on February 9. Because the tumor presented more anteriorly than posteriorly, it seemed best to approach it through the

anterior thoracic wall, and to complete the operation in one stage, if possible, so as not to interfere with the reexpansion of the lung. In two stage operations, the thickening of the pleura following the first stage of the operation often limits reexpansion. One incision was made from the base of the neck, over the juncture of the inner and middle thirds of the clavicle, to the second rib, and a second was made along the second rib from the sternum to the anterior axillary line. The pectoral muscles were severed. The second rib was found to be partially degenerated, and the anterior half was removed. The clavicle was then sawed through at the juncture of the inner and middle thirds and the first rib thus exposed. It was markedly degenerated, and the anterior half was

Fig. 4.—Fibromyxosarcoma of apex of right lung; removal of tumor by enucleation and maceration with finger.

removed. The subclavian vessels were pushed out of the field and protected by gauze sponges. Retraction of the two cut ends of the clavicle exposed the apex of the lung, and the tumor could be seen bulging through the second interspace to the apex of the thoracic cavity. Just above the first rib the tumor had crowded the lung tissue entirely out of the apex of the thoracic cavity and presented just beneath the parietal pleura. A small incision was made over the tumor, which was found to have a fairly well marked capsule, although at points it was adherent to the pleura (fig. 3). The pleura was easily separated on all sides except at the mesial portion, where the tumor was firmly attached to the vertebra by a pedicle about 2.5 cm. in diameter. It had to be torn from the vertebrate attachment, with a moderate amount of bleeding. It was neces-

sary to remove the pleura with the tumor. The size of the tumor necessitated partially breaking it in order to deliver it through the small opening (fig. 4). The muscles around the cut ends of the clavicle were sutured together and the ends of the bone, which were cut obliquely, were tied together with several strands of chromic catgut. These were placed in a groove designed for this purpose, and the wound was then closed. There was moderate shock, and the

Fig. 5.—Fibromyxosarcoma of apex of right lung; tumor 11 by 9 by 8 cm.

patient was given a blood transfusion immediately after the operation. The pathologic examination revealed degenerating fibromyxosarcoma (figs. 5 and 6).

The postoperative course was stormy for the first week. Collapse of the right lung, with bloody pleural effusion, followed the operation. The effusion was removed by aspiration three times, after which it was absorbed and the lung reexpanded. Owing to the removal of the first rib, and our inability to splint the arm because of the frequent dressings required, the clavicle did not heal by primary union but good fibrous union, and good function resulted. There was almost complete relief from the pain in the shoulder and arm.

Six months after the operation, the patient returned for observation. She was in good health and had gained 9 pounds (4.1 Kg.) in weight. There was occasional pain in the right forearm and some limitation of the motion of the right arm, due to the fibrous union of the clavicle. There was no cough, fever, sputum, hemorrhage or undue dyspnea. Horner's syndrome persisted. The lymph nodes in the axillary and supraclavicular regions were normal. There was a small hard mass just below the clavicle on the outer border of the pectoralis major. On removal it was found to be a small recurrent tumor in the substance of the major pectoral muscle, measuring a little more than 1 cm. in diameter, and of the same type as the original tumor. Radium and roentgen-ray treatments were given.

In a reply to a questionnaire, sent Sept. 4, 1926, the patient stated that her general condition was satisfactory in every respect except for slight restriction in the motion of the right arm and some shortness of breath on moderate exertion. She had maintained the gain in weight (figs. 7 and 8).

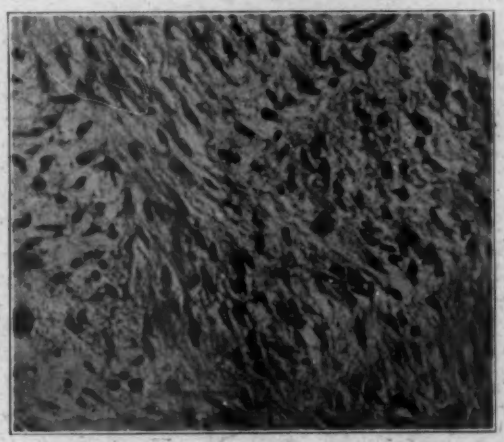

Fig. 6.—Degenerating fibromyxosarcoma; × 150.

This case is of interest because of the rarity of operable tumors in this situation. From its point of attachment it would seem that this tumor had originated in the intervertebral disk of the first and second thoracic vertebrae, and from its apparent long duration one would conclude that it probably was at first a simple fibromyxoma, which had undergone malignant degeneration. This emphasizes the necessity of recognizing intrathoracic tumors early as the possible cause of subjective symptoms other than those of a respiratory nature, and of operating early when possible. I have not found any record of a similar case in which the approach was made by cutting the clavicle. The exposure was satisfactory in this case, and the resultant slight limitation of motion of the arm was of no practical importance. I do not believe that it should be considered a contraindication to this method of approach.

Case 2.—A boy, aged 18 years, was admitted to the Mayo Clinic, April 27, 1925, because of a tumor on the left side of the chest wall. Six years previously he had fallen and injured the left side of the chest wall at about the posterior axillary line and thought that he had fractured a rib. He had experienced pain on deep breathing for about two weeks. Three years later, he had noticed a small flat tumor on one of the ribs in the region of the former injury. There was no increase in its size and no pain. One and one-half years before

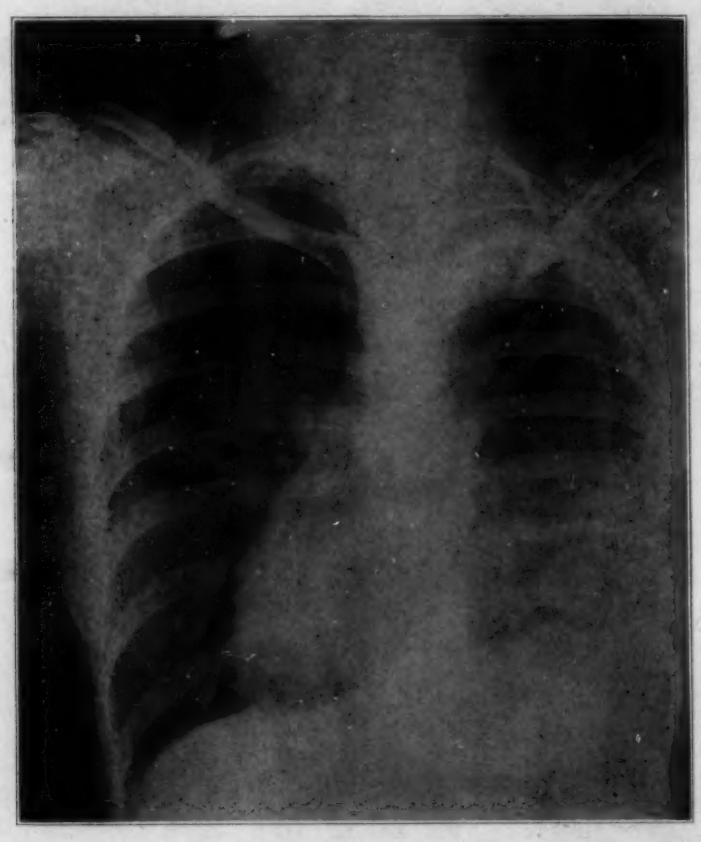

Fig. 7.—Two and one-half months after removal of tumor from apex of right lung: separation of fragments of clavicle; good fibrous union; almost complete reexpansion of lung.

coming to the clinic, he had received a second injury to the left side of the chest wall while playing football; the attending physician said a rib was fractured. Strapping the left side of the chest had afforded relief from the pain, and he had been entirely well in two weeks. The small flat tumor was still present but did not increase in size. Six months later, he noticed that the tumor was a little larger and painful on slight trauma. The tumor was then thought to be a permanent callus around the end of the fractured rib. After that time the tumor gradually increased in size, more rapidly during the last six months, until at the time of his admittance to the clinic, it was about

7 cm. in diameter. The patient felt occasional dull pain in the tumor which was more noticeable on lifting a heavy object. There was also undue dyspnea on exertion. He had lost 2 pounds (0.9 Kg.) in the last six months.

There was a tumor of the eighth left rib in the posterior axillary line, measuring about 5 by 7 cm. There was slight limitation of the motion of the left side of the chest on deep inspiration. Otherwise the general examination was essentially negative, as were the laboratory observations (fig. 9). Roentgen-ray examination of the thorax showed complete destruction of

Fig. 8.—Appearance three months after operation: Horner's eye syndrome persists; the inverted T incision on the right is healed; the lung is reexpanded.

the eighth rib posteriorly on the left side with a dense shadow involving the pleura (fig. 10). The clinical diagnosis was malignant tumor of the left side of the chest wall with extension into the thoracic cavity and involvement of the pleura, probably sarcoma. The stereoscopic and lateral roentgen-ray examination showed that the larger portion of the tumor extended deep into the left thoracic cavity, with probable involvement of the pleura, and it seemed best to remove the tumor by a two-stage operation, the first stage to be directed at walling off the pleural cavity and separating the extrapleural portion of the tumor, and the second stage to accomplish the removal of the tumor.

May 5, I removed the greater portion of the sixth, seventh, ninth and tenth ribs, sutured the visceral and parietal pleura around the tumor, resected the anterior one third of the eighth rib and cut the vertebral attachment, thus mobilizing the superficial portion of the tumor. Gauze was then packed around the tumor against the sutured pleural surfaces. May 18, I removed the tumor together with the attached pleura and a portion of the overlying skin (fig. 11).

Fig. 9.—Osteofibrosarcoma of the eighth rib at the left posterior axillary line. There was an injury at the site of the tumor at six years and at one and one-half years before examination.

There was a moderate amount of bleeding, which was controlled by a gauze pack. Moderate shock followed the operation, and physiologic sodium chloride solution was given intravenously. On the second day dyspnea increased and partial collapse of the lung was accompanied by a bloody pleural effusion, which had to be aspirated on two occasions. From the eighth day after operation the patient's condition improved gradually, and he had no further complications. The pleural effusion was gradually absorbed and the lung

reexpanded. After removal of the gauze pack, radium was inserted into the wound and, following this, intensive roentgen-ray treatment was given. The pathologic examinations showed osteofibrosarcoma, grade 2 (fig. 12).

The patient returned for examination, Aug. 28, 926, fifteen months after the operation, and no evidence of recurrence could be found. He had gained 10 pounds (4.5 Kg.) in weight. Roentgen-ray examination of the thorax showed some thickening of the pleura and full reexpansion of the lung (fig. 13). In his reply to a questionnaire, sent September 4, he stated that his general health was good and that he was working every day in an office. There was no shortness of breath, but slight pain in the chest after excessive exertion.

Fig. 10.—Complete destruction of left eighth rib, with dense shadow involving the pleura.

CASE 3.—A girl, aged 13 years, was admitted to the Mayo Clinic, March 4, 1926. She had been complaining chiefly of pain in the left arm and shoulder for two months. Two months before admission, she had fallen and injured the left shoulder, and an area of ecchymosis appeared at the site of the present tumor. Two or three days later she began to have pain in the upper part of the back and left side, which she compared to the "sticking of pins." This had persisted for several days, and then pain had begun in the left shoulder and arm, and later in the left breast and axilla. Use of the left arm increased the pain, which was almost constant and so severe at night as to prevent sleep.

Every few days there was marked aching of the entire left side of the face, which lasted for hours and required sedatives for relief. The use of "medicine" brought some relief from the pain, but no other treatment was given. There had been a loss of 8 pounds (3.6 Kg.) in weight in two months. Dyspnea on exertion had become progressively worse.

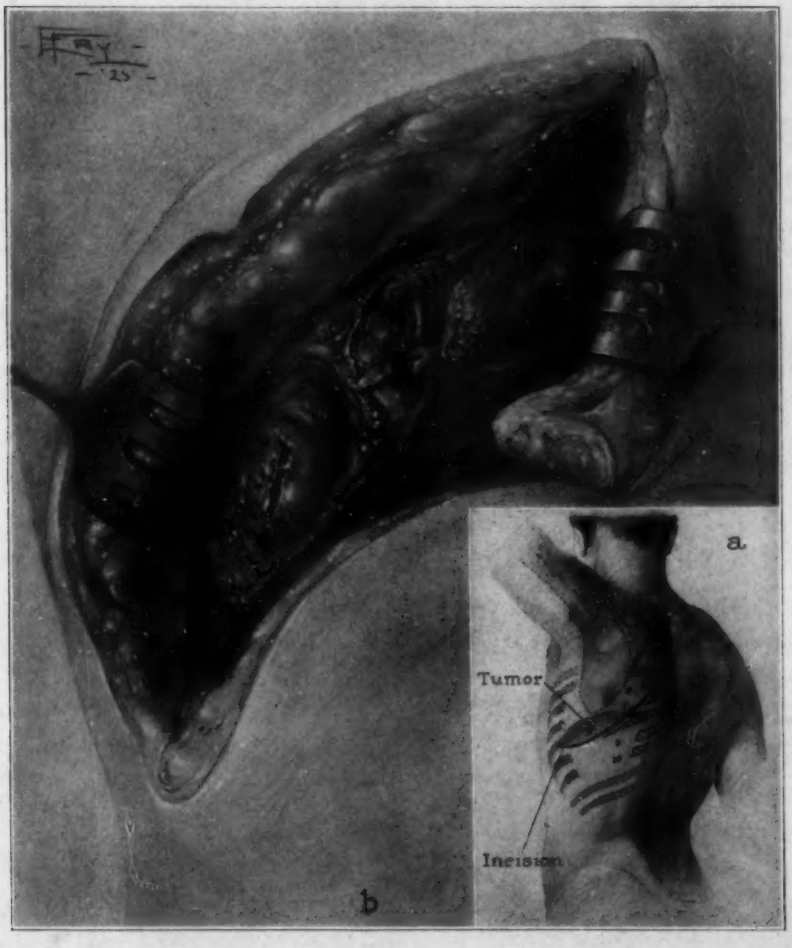

Fig. 11.—Osteofibrosarcoma on the left side of the chest wall and eighth rib (intrathoracic). Portions of the sixth, seventh, ninth and tenth ribs were removed, the pleura sutured and the anterior one-third of the eighth rib resected to mobilize the tumor.

The patient seemed to be undernourished. A tumor of the right side of the bony chest wall posteriorly involved the first and second ribs above and medial to the scapula. There was hyperesthesia of the left scapular region and marked tenderness in the left axilla. There was increased heat in the left arm and hand, and the nails of the left hand were slightly cyanotic. The pupil of the left eye was contracted, and there was ptosis of the lid (Horner's

syndrome). There was no enlargement of the regional lymph nodes. The hemoglobin was 68 per cent; erythrocytes numbered 3,910,000 and leukocytes 10,100. The Wassermann and Pirquet tests were negative. Other laboratory studies were esentially negative. The long capillaries showed no dilatation in any of the loops; there was no stasis, and the flow was even and fast. There was no difference in the capillaries of the hands. The temperature of the skin at the shoulder on the left was 34.5, right, 33.3; above the elbow, left, 32.9, right, 32.3; below the elbow, left, 35.3, right, 33; on the back of hand, left, 36.4, and right, 33.9.

Ophthalmologic examination showed that vision was practically equal, and the ocular reflexes and visual fields normal; the fundus was normal, and Horner's syndrome was present on the left. Roentgen-ray examination of the thorax showed a tumor in the left side of the upper part of the chest wall, with extensive destruction of the first and second ribs posteriorly. The clinical diagnosis was malignant tumor of the upper region of the bony chest wall

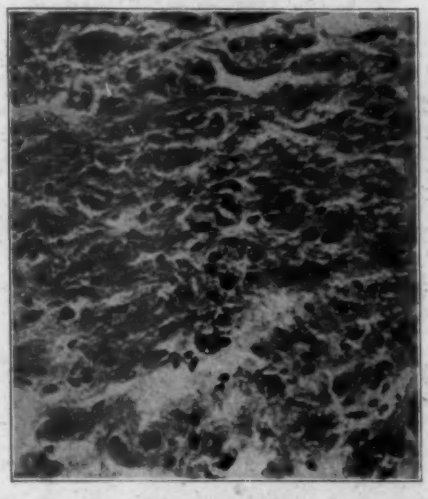

Fig. 12.—Osteofibrosarcoma, grade 3; × 170.

on the left, with peripheral neuritis from involvement of the brachial plexus and the cervical sympathetic nerve.

March 16, I explored the tumor through a vertical incision in the left side of the chest wall posteriorly between the scapula and vertebrae. The scapula was not involved, and lateral retraction of it permitted good exposure. There was an extensive infiltrating tumor which seemed to have originated in the first and second ribs, to have extended into the thorax and to have infiltrated the intercostal tissue down the posterior wall of the chest, completely encircling the third and fourth ribs and extending medially into the vertebrae. It was impossible to remove the tumor completely because of its infiltrating character. The accessible portion of the tumor was removed with the third and fourth ribs, and the cavity was packed with gauze. Later, radium was inserted into the pocket when the gauze was removed. Pathologic examination disclosed osteogenic sarcoma, grade 3.

There was moderate shock following the operation, but the patient soon recovered. Radium treatment was given on the fifth day, and the patient

returned home on the fourteenth day following operation. A poor prognosis was given, and there was only slight relief from the pain. The patient died May 7.

CASE 4.—A girl, aged 15 years, was admitted to the Mayo Clinic, Nov. 14, 1925, stating that she had had good health until five months before, when she had first noticed pain in the posterior part of the chest wall on the right, just

Fig. 13.—Fifteen months after radical excision of osteofibrosarcoma on left side of chest wall and eighth rib; the patient was 12 pounds (5.4 Kg.) above normal weight.

below the shoulder blade, when lying in bed. Gradually the pain became more noticeable until its severity caused painful breathing; for the week previous to admission, she had been confined to bed. About three months before admission (two months after the onset of pain), a tumor was first noticed in the painful region. It grew rapidly and at the time of examination it was about 7 cm. long. A specimen of tissue removed two weeks previously was reported

sarcoma. The patient had lost 5 pounds (2.3 Kg.), and appetite and strength had failed markedly during the last two weeks. There was no history of injury, and there had been no respiratory symptoms.

The physical examination was essentially negative except for a large tumor in the posterior part of the chest on the right (scapular region), which pushed the scapula upward and forward. The tumor was hard and slightly tender; it was not attached to the skin except at the site of the recent operative scar over the surface of the tumor. Regional lymph nodes were not involved. The hemoglobin was 72 per cent; the erythrocytes numbered 4,460,000 and the leukocytes 14,700. The results of other laboratory examinations were negative. Roentgen-ray examination of the thorax showed increased density over the fifth, sixth, seventh and eighth ribs and interspaces, with questionable involvement of the lung. The clinical diagnosis was malignant tumor of the right posterior region of the chest wall, probably sarcoma.

December 1, I made a large vertical incision, excising the old scar between the vertebra and the scapula, and obtained good exposure by elevating the scapula. There was a large infiltrating tumor, which involved the posterior third of the fourth, fifth, sixth, seventh and eighth ribs and intervening intercostal tissue from the vertebral attachment laterally. Macroscopically, it appeared to be malignant. The entire mass was removed, including the pleura, and the posterior half of the fourth, fifth, sixth, seventh and eighth ribs. There were areas of infiltration and thinning that indicated apparent involvement of the vertebra, which could not be removed. Radium was inserted in a rubber tube and placed along the vertebra at the time of operation. The pathologic examination showed endothelioma, grade 4. There was little shock following the operation, and there were no postoperative complications. The patient was dismissed from the hospital on the thirteenth day and returned home on the twenty-third day after operation. Relief from pain was only temporary, and about three months after the operation a recurrence involved the spinal cord and caused paralysis of both legs. The tumor recurred in both lungs also, and the patient died five months after the operation.

Case 5.—A girl, aged 3 years, was admitted, May 7, 1925, because of tumor of the right side of the chest wall. A small tumor just below the right shoulder-blade was first noticed by the parents six weeks before they brought the child to the clinic. It had increased in size rapidly but there was no pain. The child had lost 3 pounds (1.4 Kg.). The tumor had been excised elsewhere ten days before admission, and on pathologic examination it was found to be sarcoma. There were no respiratory symptoms and no history of injury.

The child was well developed but rather poorly nourished; the skin was dry, and there was an appearance of anemia. The hard, firm tumor of the right side of the chest wall in the axillary line was firmly attached to the ribs. The hemoglobin was 40 per cent; the erythrocytes numbered 3,440,000 and leukocytes 8,500, with a normal differential count. The blood Wassermann reaction was negative. The results of other laboratory examinations were negative. Roentgen-ray examination of the thorax showed a circumscribed area with increased density in the lower right lobe and pleuritic thickening at the right base as high as the fourth rib. The clinical diagnosis was malignant tumor of the right side of the bony chest wall, probably sarcoma. Because of recent operation radium was advised, and the patient was asked to return in a month for observation.

The child was brought back for observation, July 8, seven weeks after dismissal. The parents said that her condition had been good for about four

weeks and that the tumor had then reappeared. At the sixth week, she complained of pain on moving the right arm. Little change was noted on examination except for the presence of a tumor at the site of the previous operation in the right posterior portion of the thorax. The hemoglobin was 44 per cent. The roentgen-ray examination showed destruction of the eighth rib posteriorly on the right side and pleuritic thickening at the right base.

July 14, I excised the tumor, radically removing the posterior half of the eighth rib and intercostal muscles and a portion of the pleura. The pleura was adherent and the left pleural cavity was not opened. The wound was packed with gauze, and radium was inserted when the gauze was removed forty-eight hours after the operation. The pathologic report was osteogenic sarcoma, grade 4.

Convalescence was uneventful. The patient returned for radium treatment, September 9, and there was no local evidence of recurrence at this time. The hemoglobin was 38 per cent.

A letter from the child's parents stated that she had died, December 16, approximately nine months from the time the tumor was first noticed. She suffered a great deal of pain from about two weeks following the last radium treatment until death.

Case 6.—A man, aged 58, was admitted to the Mayo Clinic, Aug. 27, 1925, because of a tumor of the right side of the chest wall. Forty years previously he had been kicked in the right side of the chest by a mule, and there had been a small tumor about 2.5 cm. in diameter at the site of the injury ever since. There was little growth until six months before his admission to the clinic, but after that it doubled in size. There was no pain, loss of weight or respiratory symptoms.

Results of the physical examination were essentially negative, except for a hard, irregular tumor, 7.5 by 10 cm. in size, which was firmly attached to the fourth rib on the right. Results of the laboratory examinations were practically negative. Roentgen-ray examination of the thorax showed a tumor involving the third and fourth ribs on the right with pleural thickening at the second, third and fourth interspaces. The diagnosis was malignant tumor of the right side of the chest wall, probably sarcoma.

September 3, I resected the tumor with about a third of the fourth rib and the surrounding tissue. The tumor was about 10 cm. in length and had caused complete destruction of about one-fourth of the fourth rib. The pathologic diagnosis was chondrosarcoma, grade 1.

Convalescence was uneventful, and radium treatment was given over the affected area. A letter from the patient's physician, May 4, 1926, eight months after the operation, stated that he had examined the patient and that there was no evidence of recurrence. He was doing manual labor every day.

Case 7.—A man, aged 54, was admited to the Mayo Clinic, Jan. 27, 1925, complaining chiefly of a tumor of the right side of the chest wall. Twelve years before admission injury of the right lower part of the chest wall from a fall had been followed by soreness and severe pain over the injured area. The patient was not certain whether the ribs had been fractured. The pain had subsided in about two weeks, and there had been no further trouble until two months before admission, when he noticed a burning sensation on the right side of the lower part of the chest at about the site of the injury twelve years before. The burning continued, and in a few weeks he noticed a small immovable mass which was connected with the right lower ribs. The mass gradually increased in size, but there was no pain, loss of weight or respiratory symptoms.

The physical examination was essentially negative except for a hard, bony, fixed mass, about 5 by 5 cm. in size, which was attached to the ninth right rib at the anterior axillary line. Results of laboratory examinations were practically negative. Roentgen-ray examination of the thorax revealed a dense shadow just above the diaphragm on the right side, which was interpreted as a tumor apparently attached to the ribs and involving the pleura. The clinical diagnosis was malignant tumor of the right side of the chest wall, probably sarcoma.

February 6, I explored and found the tumor involving the eighth and ninth ribs and cartilages. The tumor was radically resected and the wound packed with gauze. Radium was inserted into the wound when the pack was removed forty-eight hours after operation. The pathologic diagnosis was chondrosarcoma. Convalescence was uneventful.

The patient returned for observation and a second course of radium treatment, April 28. There was no evidence of recurrence. He has returned periodically since for investigation and at his last visit, Sept. 10, 1926, he had gained about 5 pounds (2.3 Kg.) and was in good general condition. He was working every day and had had no respiratory symptoms, except slight pain on exertion. There was no evidence of recurrence either by physical or roentgen-ray examination.

Case 8.—A man, aged 42, was admitted to the Mayo Clinic, Aug. 10, 1925, because of a tumor of the left side of the chest wall. Two months before admission the patient had first noticed a small growth on the anterior wall of the left side of the chest. This had gradually increased in size until at the time of examination it measured approximately 7 by 4 cm. There was no history of pain, injury, loss of weight or respiratory symptoms. Electric treatments had been given; they seemed to increase the size of the growth.

The physical examination was essentially negative except for a firm tumor which was attached to the sternum on the left side of the chest and which involved the second and third ribs. Roentgen-ray examination of the thorax was negative. There was no enlargement of the regional lymph nodes. The clinical diagnosis was malignant tumor of the left side of the chest wall, probably sarcoma.

August 18, I resected the tumor widely. It presented from the second left interspace, close to the sternum, and involved the second and third cartilages, a proximal portion of these ribs and the sternum. The wound was packed with gauze and radium was inserted forty-eight hours after operation. The pathologic examination revealed lymphosarcoma, grade 4.

Convalescence was uneventful, and the patient was dismissed from the hospital on the ninth day and from observation three weeks after operation. In a reply to a questionnaire, sent September 4, he stated that he was enjoying fairly good health but had some pain and dyspnea on exertion. He was able to carry on most of his usual activities. There was no evidence of recurrence.

Case 9.—A man, aged 45, was admitted to the Mayo Clinic, Oct. 5, 1925, because of a tumor in the left side of the chest. The patient had first noticed a tumor of the left side of the chest below the scapula, six months before presenting himself at the clinic. It had increased in size gradually. There was marked limitation of the motion of the left arm for three months. There had been no pain, loss of weight or respiratory symptoms, and there was no history of injury. Six roentgen-ray treatments had not affected the size of the tumor.

Results of physical examination were essentially negative except for a large tumor at the lower angle of the left scapula presenting at the axillary border, about 10 cm. in diameter; it moved with the scapula and had pushed the scapula upward and backward. There was moderate limitation of the motion of the left arm. There were a few small enlarged lymph nodes in the right axilla. Results of laboratory examinations were practically negative, as were also those of roentgen-ray examination of the thorax and scapula. The clinical diagnosis was tumor of the left scapula and chest wall, probably benign fibroma or possibly fibrosarcoma.

October 8, I removed a large tumor, measuring 12 by 9 by 5 cm., which extended beneath and along the vertebral border of the scapula and was attached to its ventral surface, as well as to the chest wall under the scapula. The tumor was encapsulated, and enucleated easily except at its two points of attachment. Pathologic examination disclosed fibrosarcoma in a fibroma.

Convalescence was uneventful. Intensive radium treatment was applied over the area affected. In a reply to a questionnaire of Sept. 4, 1926, the patient stated that his general health was excellent, that he carried on all his usual activities and that there was no limitation of the motion of the arm. He had gained 12 pounds (5.4 Kg.), and there was no evidence of recurrence of the tumor.

CASE 10.—A woman, aged 46, was admitted to the Mayo Clinic, June 23, 1925; two years previously the left breast had been removed for malignant disease. Four months before coming to the clinic, the patient had noticed a tumor in the right breast and this had increased gradually in size. There was no pain, loss of weight or respiratory symptoms, and no history of injury. There was a postoperative scar from removal of the left breast two years previously, without evidence of recurrence in the scar or regional lymph nodes. There was a hard mass beneath the lower medial quadrant of the right breast, which was fixed to the chest wall at the fifth rib. There was no enlargement of the axillary lymph nodes. Results of laboratory examinations were practically negative, as were those of roentgen-ray examination of the thorax. The clinical diagnosis was malignant tumor of the right wall of the chest, probably sarcoma or metastatic carcinoma.

July 2, I resected the tumor and about 7 cm. of the fifth rib and the surrounding tissue, including the cartilage and a portion of the sternum. The pleural cavity was not opened. The wound was packed with gauge and intensive radium treatment was given later. The pathologic diagnosis was lymphosarcoma, myeloma type. Convalescence was uneventful.

The patient returned for observation, November 24, and was in good general condition. There was no evidence of recurrence. In a reply to a questionnaire, sent Sept. 4, 1926, she stated that her health was good and that she was doing practically all her own work. She had gained 22 pounds (10 Kg.) in weight. She had some pain in the right side of the chest and spine when especially tired. There was no evidence of recurrence of the tumor.

CASE 11.—A woman, aged 29, was admitted to the Mayo Clinic, July 5, 1926, stating that five years before admission she had first noticed a small nodule in the posterior part of the chest wall on the right. There was no history of injury, soreness or pain. The tumor grew slowly for two years, and then began to enlarge rapidly and attained a diameter of 10 cm. in one and one-half years, at which time it first caused pain. The tumor was excised elsewhere one and one-half years before she came to the clinic. Two or three months

after the operation, she again had pain and noticed that the tumor had recurred. The recurring tumor was removed seven months after the first operation and six roentgen-ray treatments were given. The tumor never disappeared entirely after the second operation, and for the month before the patient came to the clinic it had rapidly increased in size. The pain interfered with sleep. She had lost 16 pounds (7.3 Kg.) during the last three years and 8 pounds (3.6 Kg.) in the five months preceding our examination. There were no respiratory symptoms.

Results of physical examination were negative except for evidence of loss of weight and a hard, firm, immovable tumor about 10 by 10 cm., just to the right of the spine on the right side of the lower part of the thorax. There was an old operative scar over half of it. Results of laboratory examinations were practically negative, as were those of roentgen-ray examination of the thorax and of the spine. The clinical diagnosis was malignant tumor of the posterior region of the chest wall on the right, probably sarcoma.

July 8, I removed the eleventh and twelfth ribs on the right posteriorly. A portion of the pleura was removed with the tumor, which extended deep into the lower pleural cavity. The operation was followed by treatment with radium and roentgen ray. The pathologic diagnosis was fibromyxosarcoma.

Convalescence was uneventful, and the patient was dismissed from the hospital, July 26. She returned for a second course of radium and roentgen-ray treatment, September 1. As only three months have elapsed since the operation and the tumor was of the malignant recurrent type, it is too early to draw any conclusions as to the ultimate result.

Case 12.—A woman, aged 44, was admitted to the clinic, July 27, 1925. Six months before admission she had felt a pain in the anterior portion of the chest on the right and had noticed a lump in the chest wall. The tumor had gradully increased in size, especially during the last few weeks, and there was some pain in the tumor on palpation and some pain in the right arm. Otherwise there had been no pain since the onset. There was no history of injury, no loss of weight and no respiratory symptoms.

The patient's general condition was good. There was an enlargement of the wall of the chest on the right anteriorly, extending from the sternum to the nipple line, and from the second to the fourth rib. The mass appeared to be hard and fixed to the chest wall. The clinical diagnosis was tumor of the wall of the chest on the right, probably sarcoma because of its rapid growth.

At operation, August 4, I found the second and third ribs markedly thinned out anteriorly; a portion of the third rib and cartilage was resected for diagnosis. The pathologic report stated that the rib was markedly thinned in the anteroposterior dimension as though there had been pressure; the maximal thickness was 2 mm., with practically no bone marrow; there was probably an old healed fracture of the third rib.

Case 13.—A woman, aged 57, was admitted to the Mayo Clinic, June 29, 1925, stating that she had had pneumonia four months before admission and had accidentally noticed a lump in the right breast at that time as the chest was sore. Enlargement of the lump had been noticed about six weeks before admission and continually since then. There was no pain and no history of injury. She had lost 22 pounds (10 Kg.) at the time she had pneumonia, and there had been no gain or loss since then. There was some undue dyspnea on exertion.

Examination disclosed a tumor at the level of the fourth rib, under the lower medial quadrant of the right breast. It was hard and fixed to the chest

wall, and was not painful on pressure. Results of the laboratory examinations were practically negative, as were those of the roentgen-ray examination of the thorax. The clinical diagnosis was malignant tumor of the wall of the chest on the right.

July 21, I drained a tuberculous abscess under the right pectoral muscle which had originated in the chest wall, probably from the eighth to the ninth costal cartilage. Convalescence was uneventful.

In a reply to a questionnaire of Sept. 4, 1926, the patient stated that her general condition was good and that she was able to carry on most of her usual activities. There had been no loss of weight. She suffered more shortness of breath on exertion than normally.

CASE 14.—A woman, aged 29, was admitted to the clinic, Aug. 7, 1925, her chief complaint being pain and tumor in the right side of the chest. Six years previously, she had received a blow on the right side of the chest and since that time had experienced occasional pain. She had been struck again in the same place one year before admission and the pain had been more pronounced since that time. She had first noticed the tumor of the rib several months before admission. Pus had drained from the right breast periodically for the last three to six years. The lymph nodes under the right arm had been painful for the last six months, and there had been pain on motion of the right arm. The patient had many other irrelevant complaints. She had lost 5 pounds (2.3 Kg.) but had had no respiratory symptoms.

There was prominence of the third rib on the right with tenderness on pressure. Roentgen-ray examination of the thorax showed slight density at the right fourth intercostal space. The clinical diagnosis was old fracture of the fourth rib with callous formation. Conservative treatment was advised.

The patient returned, September 1, greatly worried about the tumor, stating that pain was severe and constant and that she feared malignancy. There had been no change in the character of the tumor, but the patient wished a positive diagnosis. Exploration was advised.

At operation, September 3, I found an old fracture of the third rib anteriorly with exostosis of the bone. The pathologic diagnosis was exostosis, probably old fracture. Convalescence was uneventful.

CASE 15.—A woman, aged 37, was admitted to the Mayo Clinic, Feb. 25, 1925, her chief complaint being tumor of the anterior chest wall. Five months before she came to the clinic she had first noticed a tumor of the third left costal cartilage. There was no history of injury or pain. The tumor increased in size slowly and the patient worried about malignancy. There was no loss of weight and no respiratory symptoms were noted.

There was a small tumor of the third rib at its juncture with the cartilage. Roentgen-ray examination of the thorax was negative. The clinical diagnosis was tumor of the left anterior portion of the chest wall, probably benign.

The patient returned, October 7, greatly worried because the tumor seemed to have increased in size and had become somewhat painful. Her general condition was unchanged, but she was nervous and worried. She had gained 10 pounds (4.5 Kg.),

October 8, I removed the cartilage and about 2.5 cm. of the third rib. The pathologic diagnosis was achondrosis of the costal cartilage. Convalescence was uneventful.

CASE 16.—A woman, aged 32, was admitted to the Mayo Clinic, Sept. 15, 1925, stating that seven years previously she had first noticed a lump in the right breast. It had increased in size slowly for six years and had been painful

for the last two years. The pain had been more pronounced during the few weeks before admission to the clinic. There was no loss of weight, no history of injury to the chest wall, and there were no respiratory symptoms.

The results of physical examination were essentially negative except for increased prominence of the fourth rib beneath the right breast. The results of the laboratory examinations were practically negative. Roentgen-ray examination of the thorax was negative. The clinical diagnosis was tumor of the fourth rib on the right, probably benign.

September 22, I explored, and on exposing the fourth rib found marked thickening and bulging of the cartilage. A portion of the cartilage of the fourth rib was removed for diagnosis. The pathologic report was multiple areas of necrosis of cartilage. Convalescence was uneventful.

In reply to a questionnaire, sent Sept. 4, 1926, the patient stated that her general condition was good. She was carrying on her usual activities and had no complaints.

ABSTRACT OF DISCUSSION

DR. HOWARD LILIENTHAL, New York: I should like to call attention to a point in the after-treatment in cases of this kind and also in the treatment in absolutely inoperable cases, that is, the sarcomas involving the chest wall. I have used the erysipelas and prodigiosus toxins of Coley many times and I have had good success. I think they alone promise an actual cure. Radiation and radium cannot cure. They act locally. A child, aged 2 years, had a sarcoma which involved the mediastinum. It was apparently an inoperable case. The child had been completely paraplegic for several weeks before I saw her, late in the disease. Two ribs had been eroded. I performed a posterior mediastinotomy and removed a specimen about half the size of an egg, which was only a small part of the tumor itself. It proved to be a lymphosarcoma. With no other treatment than Coley's serum, the child was walking in six weeks. She is now over 4 years old. She still has an opacity; evidently some of the tumor is still present in the mediastinum. The ribs have recovered their contour, and the mother refuses to permit further treatment. I think, however, that the child should be treated further. This is only one case, but I have had others. The reason I am mentioning this case is on account of the striking symptom of complete paraplegia. The child was unable to walk and the legs dangled. Now she runs about and seems to be perfectly well. In the cases accompanied by Horner's syndrome, it is rather important in securing the history to get the chronology of the symptom of Horner's syndrome—whether it comes early or late—because it will give one an idea of the place of origin of the tumor. These tumors are likely to spring from the upper thoracic sympathetic ganglions.

DR. WILLY MEYER, New York: Dr. Harrington mentioned metastatic malignant tumors of the chest subsequent to radical excision of the breast for cancer. I have just attended the cancer symposium at Lake Mohonk, and I was impressed when I heard there of a second case—a successful case had been reported by Sauerbruch—in which the total excision of the chest wall was performed by Dr. Semken of New York for a late local recurrence. The patient was still alive two and one-half years after the second operation and remains under observation. Results like these should encourage us to take radical measures in cases of this type.

I should like to mention a case of mine which, after wide resection and microscopic examination, proved to be a metastatic cancer of the chest wall of the hypernephroma type. Several months later the patient developed metastases of the

skull and scapula. I myself when operating on these patients always add air-tight drainage of the pleural cavity for two or three days. It excludes worry in the first days after operation, as the often abundant secretion of the pleura and the parenchymatous bleeding from the resected ribs into the pleural cavity can be drained off by this method.

Dr. Carl A. Hedblom, Chicago: The end-result following operation for sarcoma of the thorax is discouraging. The operation is worth while in the majority of cases because life is prolonged and the patient made more comfortable, but if one studies the end-results after a period of years, as in a series of 200 chest wall tumors that I reviewed some years ago, one is struck with the fact that practically without exception these patients die of sarcoma. One patient in the Mayo Clinic series lived six years and one was symptom-free after twelve years. Dr. Harrington's cases, with the one exception of the epithelioma, were all cases of sarcoma of some secondary type. The point I wish to make particularly is that a large proportion of the cases of sarcoma begin as nonmalignant tumors, particularly chondroma, and it is during this stage of the tumor that we can hope for a permanent cure if only we can get the family physician, who sees the patient first, to realize the importance of prompt treatment as soon as the tumor is recognized. Of course, a considerable proportion begin as sarcoma, and in such cases this argument does not apply. But I have seen chondroma and osteochondroma present from five to twenty years before the onset of symptoms indicating malignant changes. One other point as to differential diagnosis: When the tumor is small, it may be difficult to decide whether one is dealing with a neoplasm or with an unnatural bulge of a rib. I have had several such cases, and I have taken the attitude that it is better to perform exploratory operations for a simple abnormality of the rib than to miss a neoplasm in the early stage. I have found in some such cases that the appearance of a tumor was produced by a bulging, usually of the second or third rib at the costochondral junction, at which the rib would seem to have grown longer than the normal length and so have caused a bulge of the rib at that point. I have excised several such bulging ribs without any complications resulting.

I was much interested in Dr. Lilienthal's suggestion. In these cases of sarcoma anything that may seem promising is worth a trial, but I would plead especially for emphasis on the point that any tumor of the chest wall should be dealt with radically during the early stage. In that way, we will be able to remove growths before they have developed malignant changes.

Dr. Leon T. LeWald, New York: I wish that Dr. Harrington would give us further suggestions as to the differential diagnosis between benign and malignant tumors of the chest. Dr. Hedblom has emphasized exploration as one way of diagnosis. In one case which I saw, the posterior diagnosis of malignancy was not made until there was rib involvement. The man was 63 years old. He had had pain and cough for six months. The lesion was considered at first to be an encysted empyema until a negative puncture was made. The diagnosis of a malignant tumor was not suspected. At the time that Dr. Green and I saw him, after a number of exposures had been made producing roentgenograms with variations in density, we deliberately overexposed the film, and by thus penetrating the tumor mass and blotting out all lung detail, we were able to show definite rib involvement. The diagnosis was confirmed by operation. The tumor was an epithelioma and was inoperable. The patient died shortly afterward. Are there any criteria for the differential diagnosis between benign and malignant tumors growing slowly?

DR. EDWARD ARCHIBALD, Montreal: I should like to relate briefly a case of my own. A child of 7 years presented a tumor on the right side of the chest. It was difficult by any means at our disposal to determine whether it began in the lung or in the rib. Operation later showed that it had invaded the lung, involving the middle lobe to such an extent that there was little normal tissue left in that lobe. We ultimately came to the conclusion that it had begun in the rib and had extended into the lung as a fibrosarcoma, consisting chiefly of small, round cells. The operation was interesting in the sense that after taking out the section of chest wall surrounding this tumor and entering the pleura, which was adherent, one could lift the middle lobe of the right lung, which formed an integral part of the whole mass, almost completely outside the chest wall. It was a simple procedure to clamp off the healthy lung on either side and cut it away, sew it up, and drop it back. The patient therefore ran a continuous fever, due chiefly to sarcomatosis, and died in the course of three months, with metastasis through the body, particularly in the scalp.

In another cases of fibromyxosarcoma of the chest six operations were performed. Finally, the patient went to Liverpool to consult Blair Belle and receive the lead treatment. He was able to take only four injections, as they caused severe cramps, both in the abdomen and in the legs; they did not benefit him. Recently he returned to this country with a recurrence of his fibromyxosarcoma and suggestive signs in the lung, although that could not be definitely determined by the roentgen ray. I mention the lead treatment because this was a case in which it might have accomplished good, as the tumor was malignant only locally while under observation for more than a year, yet lead accomplished nothing.

DR. J. J. SINGER, St. Louis: I want to make this suggestion in the differentiation between a tumor of the chest wall and a tumor of the thorax: By the introduction of a diagnostic pneumothorax one can easily push the lung away and tell where it is, assuming, of course, that there are no direct adhesions between the lung and the tumor of the chest wall.

ANESTHESIA IN EXTRAPLEURAL THORACOPLASTY FOR ADVANCED PULMONARY TUBERCULOSIS

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The surgical treatment of tuberculous patients who no longer respond to a medical or hygienic regimen is beginning to be the accepted procedure in this country, to the great satisfaction of those who have long believed in its efficacy and the possibility of thus bringing help to many patients in an advanced stage of disease.

It is recognized that these patients should not be obliged to travel many hundreds or thousands of miles in order to find specialists who are able to establish the proper indication for operative intervention, and to carry out the required work intelligently and correctly in all its details during and after the operation. It is therefore to be expected that soon every large city in America will have competent medical men who have seen, examined and studied patients of this type from the medical roentgenologic and operative points of view and who have exchanged views and are masters of the required technic. For here the proper regard for details helps in the successful issue of the case in hand; here the harmonious and willing cooperation of internist or phthisicist, of roentgenologist and surgeon will achieve triumphs. Teamwork with the elimination of the personal equation is the watchword; the patient's welfare, the slogan that governs.

That all details in this development will require separate discussion is evident. One of these is the anesthesia. This should be the same as in other parts of the body, local with regional analgesia, general inhalation anesthesia, colonic and a combination of two or more of these.

Always to have the patient's best interest at heart, adapting the method to the patient and not the patient to the method, is a paramount requirement. It does not seem wise to me for the surgeon to say, "In my service all these patients are operated on under general anesthesia," or, "I use only regional and local anesthetics," for he has to deal with such widely differing conditions in these chronic patients that no standardized treatment can do justice to all. One may have a cavity in the upper lobe, the other an additional localized empyema, the third an empyema fistula with involvement of the opposite apex; one may have retained his original morale and undergo the operation with courage and confidence, the other may have lost it completely. For the latter to remain conscious and able to watch the various steps of the operation, although he suffers no physical pain, would mean an addi-

tional psychic ordeal, which should be avoided if possible. The mental make-up of the patient should receive special consideration, particularly when it appears advisable to operate in stages.

The gist of these reflections is the necessity for the operator to master the various procedures that make the surgical work painless and, as far as possible, safe.

LOCAL AND REGIONAL ANESTHESIA

Today there can be no question that from the standpoint of safety local and regional anesthesia in the chest, as well as elsewhere, occupies first place. It is evident that if in the presence of a chronic lung suppuration, for instance, the patient retains the ability to sense irritation and the ability to expectorate, he is better off than without these powers. Yet individual characteristics may present a clear contraindication to the method stated and force operators to employ the next best procedure, and trust that it may prove equally beneficial.

For the operation of extrapleural thoracoplasty a variety of well worked out methods are at the surgeon's command. He will naturally select the one that in his opinion involves the least amount of risk for the patient, and train his staff in this method. If he does not wish to prepare the patient himself, he can turn this part of the work over to the anesthetist before he starts the superficial as well as the deep surgical work required during the operation; every anesthetist should be master of a reliable, harmless technic. Or, the surgeon himself can proceed with the primary analgesic work in the soft parts and then, under the guidance of his eyes, expose and inject into or around the individual intercostal nerves as they present themselves as near the spine as possible.

For a complete primary preparation the so-called Kappis and Schumacher methods are at our disposal. I myself used the Kappis paravertebral method exclusively in my earlier operations for multiple rib resection in bronchiectatic and tuberculous patients. But in view of a few experiences several years ago and the additional warnings found in the literature,[1] I was induced to give up the procedure in spite of its advantage in permitting one to reach the thoracic nerves near their origin and their communication with the ganglions of the sympathetic system. In one of my cases, a bronchiectatic, profound collapse occurred on the table before the operation was commenced. I had no doubt that the point of the needle had entered the subdural space here or there. The operation had to be postponed for several days and then carried out with a combination of local, regional and superficial

1. Friedrich, H.: Centralbl. f. Chir. **53**:1441 (June 5) 1926.

inhalation anethesia, a straight general anesthesia having been deemed inadvisable in view of the large amount of expectoration present. In a second case, also bronchiectatic, the symptoms of deep collapse set in after operation. Little blood had been lost; only a superficial additional inhalation anesthesia had been employed. The collapse, which did not yield to any kind of subcutaneous or intravenous stimulation, could be attributed only to the method of regional anesthesia.

The Schumacher method, which reaches and infiltrates the nerves at the costal angle, appeals more to the surgeon than the Kappis method, and is a safe procedure. In the hands of Sauerbruch, in whose clinic it originated, and in those of many other surgeons, including myself, it has given satisfactory results, although occasionally the analgesia has been reported to have been incomplete.

It might be a good plan to make it a rule first to anesthetize skin, fascia and muscles and inject each thoracic nerve as it presents itself in the course of the operation at or beyond (medially) the angle of the rib. I believe this procedure has already been accepted as the best and most reliable by many surgeons. The question as to whether the nerves should then best be anesthetized locally with a 0.5 per cent epinephrine hydrochloride-procaine solution injected directly with alcohol, or resected, has not been settled definitely. It seems desirable that different operators should try out these methods in this particular respect and publish the observations made certain a short time after operation, and the after-effects by means of the follow-up system. To know whether the immediate postoperative pains usually observed are reduced or totally absent; to know how long it usually takes for sensation to return after direct alcohol injection, whether the prolonged absence of sensation is in any way annoying to the patient, and similar points is of greatest interest to the prospective operator and will be a valuable guide to him.

GENERAL INHALATION ANESTHESIA

I consider it not to the best interest of tuberculous patients to be subjected to a straight ether and oxygen or a gas-oxygen anesthesia, nitrous oxide or ethylene, with a mask placed tightly over the mouth and face. From a prophylactic point of view this method certainly must be inferior to others. Our aim when operating on tuberculous patients should be to hold in check as much as possible aspiration within the lung as well as the discharge of saliva and of mucus in larynx, trachea and bronchial tree; ether inhalation increases the latter. If it is necessary to use straight inhalation, a procedure should be used which permits of holding the mask a distance from the mouth to give the patient a chance to inhale plenty of air. I have reference to the drop method, employing, for instance, a mixture of chloroform, ether and

ethyl chloride. This is a narcotic the boiling point of which is adapted to the temperature of the body; for this reason it is safer than pure chloroform and safer also than the old Billroth mixture.

COLONIC ANESTHESIA

Colonic anesthesia is best combined with inhalation anesthesia, according to the indications. The great advantages offered by this method of inducing analgesia are principally due to Gwathmey's happy conception of mixing the ether with olive oil. When so prepared, the anesthetic is gradually and slowly given off; it is absorbed by the blood that circulates in the intestinal mucosa, passes with the blood through the liver and right side of the heart and is then continually given off to the outflowing respiratory volume of air in the alveoli of the lungs and in the bronchial mucosa. The patients are semiconscious and able to expectorate without experiencing pain.

Experiments on animals have shown that the effect produced by a slow and steady discharge of ether within the respiratory system is equal to an artificial hyperemia which, according to Bier's method of hyperemia, has a good, not a destructive or dangerous, effect on the patient's lung. This at least has been observed in cases of acute bronchitis and threatened pneumonia subsequent to ether inhalation anesthesia, also in patients suffering from chronic bronchitis due to alcohol or tobacco.[2] Here the ether was administered by intramuscular injection into the gluteal region, 8 minims (0.5 cc.) of ether mixed with an equal amount of sterile olive oil. By proceeding in this way the whole volume of ether also does not enter the blood at once as in the ordinary hypodermic application, but it is given off, step by step, from the artificially made deposit within the muscular substance.

There is to my mind no reason to expect harm from the use of this method in the specific types of chronic pulmonary inflammation, such as tuberculous and syphilitic, or in nonspecific suppuration of the lung. Clinical observation will soon decide this point.

In a recent case of mine this form of inducing sleep and analgesia proved to be of invaluable merit:

A much reduced, highly nervous tuberculous patient of Italian extraction needed extrapleural thoracoplasty. The right side alone was involved; pleural adhesions prevented the continuance of artificial collapse of the lung, which had been tried for some time. A two-stage operation appeared advisable, the first stage (lower ribs) to be performed under procaine, regionally and locally applied. The patient herself was unaware of the necessity of a second operation. Her psychic state forbade my telling her; the relatives, of course, knew. The prepara-

2. Riess: München. med. Wchnschr. **72**:758 (May) 1925. Seidl: ibid. **73**:95 (Jan.) 1926.

tions for the second stage were made in her room; she thought she was to have an enema, as she had been receiving them frequently. As a deep colonic anesthesia was not desired, less than the usual quantity of ether-oil was given, yet she fell asleep in her bed and did not know she was being transferred to the operating room. A few additional whiffs of anesthetic, administered by an expert, allowed me to carry out the required excision of the upper ribs, including the first. The patient awoke in her room. There was the same perfect primary union of the wound as after the first stage. She was at the hospital five weeks in all. Two months after the second operation, tubercle bacilli could not be found in the sputum on careful search; they had been plentiful when looked for before the surgical work was started. She is now recovering from the unilateral pulmonary tuberculous affection.

Of course the second stage could have been performed under regional and local anesthesia; it could also have been performed under the straight inhalation anesthesia. But that would not have been to the best interest of the patient; it would have meant adapting the patient to the method, instead of the method to the patient.

I am unable to present a series of similar observations, but the experience gathered from one carefully followed case is of value. I have no doubt that a number of members of our association have availed themselves of the advantages offered by colonic anesthesia and its combinations when performing this operation. I feel that a great deal of good can be rendered patients suffering from tuberculous pneumonitis, to whom extrapleural thoracoplasty holds out the only hope of improvement or cure, by carefully selecting the narcotic procedure and remembering colonic anesthesia.

The foregoing holds good, it seems to me, for operations for non-tuberculous lung inflammation, in fact, for thoracic operations in general. Gas positive pressure anesthesia should be added when open pneumothorax is encountered.

ABSTRACT OF DISCUSSION

Dr. A. L. Lockwood, Toronto: I feel justified in making an effort to defend paravertebral anesthesia. I circularized 200 different men in regard to whether they were doing paravertebral anesthesia by simply catching the nerve at the angle of the rib. I have employed it in 3,000 cases over a period of fourteen years. I have seen only one case in which there was any reaction. In that case I injected in the cervical block. I have stopped doing this. While talking to a group of men present, I injected too much solution. A ptosis in one eye resulted. The woman was not an extremist at all, but she developed partial paralysis of the left arm; this cleared up in ten or twelve days. I have entirely abandoned cervical paravertebral anesthesia, because I do not believe that there is any indication that one can do much with straight local anesthesia from the cervical region down. I have been employing paravertebral anesthesia, in general, as well as thoracic anesthesia, particularly in renal surgery. Probably the greatest bugbear in surgery is the matter of anesthesia. If surgeons can adopt a measure that will take the sting out of anesthesia, they should do it. I agree with Dr. Meyer

that only 1 per cent of procaine should be used as an anesthetic, and after treatment 5 per cent.

Dr. Willy Meyer, New York: After having thought of my personal experience and studied the literature, and seen an unfortunate older patient this summer, I am through with the paravertebral method of anesthesia. This patient had had a persistent intercostal neuritis subsequent to a herpes zoster. She was admitted to a hospital and placed in the care of an expert in paravertebral anesthesia for angina pectoris. She walked to the operating table. The specialist made the injection with alcohol. The woman was asked to get up. She could not. She had to be lifted onto a stretcher and brought to her bed because of a total paralysis of the lower portion of the body, bladder and rectum, which continued and soon took her life. One such case is enough for me.

PRELIMINARY ARTIFICIAL PNEUMOTHORAX IN OPERATIONS ON THE OPEN CHEST

WITH CLINICAL OBSERVATIONS ON THE SENSIBILITY AND REFLEXES OF VARIOUS PARTS OF THE LUNG, AND VARIOUS METHODS OF ANESTHESIA *

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If the silence of the last ten or fifteen years is an index, it may be assumed that the question of anesthesia in operations on the chest has been solved satisfactorily. This is true for most of the operations surgeons are called on to perform. Procaine hydrochloride, aided occasionally if not regularly by a light nitrous oxide narcosis or a few whiffs of ethyl chloride, gives a satisfactory anesthesia for extrapleural operations—thoracoplasty, avulsion of the phrenic nerve, extrapleural operations on the esophagus and also for more or less extensive thoracotomies when the lung is fixed by a thick and rigid pleura. Local anesthesia with or without nitrous oxide is also satisfactory in that type of operation which we have been led by Evarts Graham to use in suppurative disease of the lung: chronic abscess, chronic suppurative pneumonia and bronchiectasis—a type in which the lung is entered after it has been caused to adhere to the pleura.

Anesthesia for operations that necessitate wide openings into chests containing a mobile lung and mediastinum, however, is still far from satisfactory; and it is toward this kind of attack that surgery of the lung must trend if it is to move with that freedom which open exploration has enabled surgeons to acquire in dealing with the abdominal viscera. Present methods of handling the lung, the intentional provocation of adhesions and obliterative processes, are those which were used in the infancy of abdominal surgery. They are not the ideal to be striven for; they hamper exploration and vision. And while I realize that this cautious and gradual plan of attack has saved many lives and made operations on purulent lungs safer than they were when surgeons were bolder in entering the chest, I feel that the time will come when a better insight into the present difficulties will allow greater freedom, and that the future will lie in open thoracotomies that allow one to feel and see, rather than that in semiclosed operations that confine the maneuvers to small, sealed and unexplorable areas.

The dangers and difficulties of wide thoracotomy lie chiefly in sudden collapse of the lung and in that mysterious phenomenon known for want

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of a better term as a "pleural reflex." To these there is added, whenever the larger bronchi are approached, a cough reflex. If operators can learn to cope with these three factors, the sudden collapse, the pleural (I think rather, pulmonary) reflex and the cough, it will be possible to work with freedom in the open chest.

Sudden collapse is not the correct term for the chief difficulty. All sudden variations in lung volume, both sudden collapse and sudden inflation, are equally objectionable. Both make a sudden variation in the volume of blood that is thrown into and sucked out of the heart. Both are equally terrifying in their effects on the circulation.

Positive and the older negative pressure methods partly avoid a sudden collapse, of course—partly but not entirely, for the lung is purposely inflated and allowed to collapse during all the pressure methods of anesthesia. Nearest perfect is Branower's method, which so cleverly balances the pressure that the lung in the unopened side of the chest is kept working and the mediastinum kept in place while the lung in the open side of the chest is allowed to collapse. Even here it seems necessary occasionally to inflate the lung. Branower says, "The anesthetist should carefully observe the condition of the operative lung from time to time, and should frequently request the surgeon for an opportunity to inflate it. This has a wonderfully stimulating effect upon the patient." Even this delicate method seems to tax the powers of a patient severely. Branower states that "an operation of more than forty to forty-five minutes' duration is not likely to be followed by recovery."

The pressure method, therefore, has its inherent disadvantages. It is interesting to see how quickly it tires a normal person to breathe against a pressure mask, although this effort is only a small part of the strain of a pressure anesthesia. Even were it possible to keep the lung evenly distended, the surgeon would have no room to work. He needs a certain amount of collapse. If the lung is kept distended, the patient does not get rid of his tidal air; on the other hand, he cannot stand its being kept collapsed. The necessary alternative is an occasional variation from collapse to distention. This shift is a strain on the surgeon, for each time it occurs his field shifts many inches, and he is forced again and again to readjust his manipulations. Much more is it a strain on the patient's heart, so terrifying a one that I thank God every time I am able safely to complete an operation when I have entered the chest under positive pressure. It is impossible to work with equanimity under these distressing difficulties.

Is it possible, then, to avoid the respiratory and circulatory disturbances that accompany these sudden changes in the volume of the lung? It is. The disturbing element in the changes is their suddenness. If they can be made gradual, if the lung can be collapsed, and before the chest is opened the negative pressure abolished in it, if the

patient can be allowed sufficient time to accustom himself to the change in his respiratory volume, he will not breathe otherwise when his chest is open than when it is closed. This gradual reduction of the respiratory volume can be accomplished easily by inducing an artificial pneumothorax, in several sittings a week or so before operation. It is astonishing when this has been done to see a patient lie breathing quietly with an opening in the chest wall into which one can easily introduce a fist.

The method has the further advantage of emptying a suppurating lung of secretions, and keeping it empty. When it is used, one no longer sees pus stream in cupfuls from the patient's mouth and nose, as it does when a suppurating lung is suddenly collapsed. The collapsed lung, except for the suppurating area or the bronchiectatic pouches it may contain, is dry and empty.

Preparatory gradual pneumothorax is useful in all free thoracotomies; in tuberculosis it is imperative, for it is extremely harmful suddenly to collapse and distend a tuberculous lung with a positive pressure machine. The method of preparatory pneumothorax seems to have possibilities, perhaps even to open a few new vistas in pulmonary resection for tumors, for inflammatory processes, occasionally even for tuberculosis. Its use is not confined to pulmonary disease; in intrathoracic esophageal tumors it gives an excellent oversight, and it immediately disposes of the powerful suction above the diaphragm which forms the main difficulty in the treatment of diaphragmatic hernia.

Not having Branower's apparatus, and being forced at times to work with anesthetists of varying skill, I have used preparatory pneumothorax only in conjunction with local and rectal anesthesia. If, however, one has an anesthetist whose delicacy is equal to maintaining the balance that Branower calls for, i. e., a pressure that will keep the good lung working and the bad one collapsed, there should be no reason for not combining the method with Branower's inflation anesthesia.

I have used the preliminary pneumothorax and local anesthesia either alone after an injection of morphine and atropine, or in conjunction with rectal anesthesia. For rectal anesthesia, morphine-atropine is given one hour before operation, followed in fifteen minutes by 2 or 3 ounces (59 or 89 cc.) of ether, 2 drachms (7.8 Gm.) of paraldehyde and 2 ounces of olive oil instilled slowly into the rectum. The rectal anesthesia when it works, works well; however, about one patient in three or four is excited instead of being put to sleep by it—an annoying complication, making operation difficult. The patient must not cough or talk; if he makes an expiratory effort against a closed glottis, he will balloon out his collapsed lung. This has happened twice in a series of eleven cases. When it does happen, the incision must be sealed with a wet towel and the patient quieted before operation can proceed.

Finally, the mild inflammatory thickening that results from the presence of air in the pleura is not the least of the advantages of preliminary pneumothorax. The stability of adhesions, once they form in an artificial pneumothorax, is notorious. Adhesions form quickly and firmly after operation, i. e., at a time when they are desirable. Absorption from the thickened pleura seems to be less sudden and less dangerous than from a normal one, so that the mild pleurisy is a protection in lobectomies and other operations in which the pleura is likely to be contaminated with pus.

I shall not reopen the question of open lobectomy versus the cautery operation here. I am ashamed of the mortality after my lobectomies. However, the preliminary pneumothorax seems to give hope for lobectomy in bronchiectasis, an operation which (if it could be carried through with equal safety) would be preferable both in quickness and completeness of recovery to repeated cauterization.

Pleuritic adhesions may make it impossible to induce an artificial pneumothorax. When pleurisy occurs it usually accompanies suppurative affections of the lung, which call for drainage and not for extensive resections of a part or all of a lobe: in this type of operation free thoracotomy is uncalled for; pleurisy is welcome and necessary before the chest is entered.

In bronchiectasis, in tumors and in diseases of the esophagus and mediastinum that call for a wide open thoracotomy, adhesions rarely interfere with induction of a pneumothorax.

Preparatory pneumothorax has been used in eleven cases: five intrapleural pneumolyses for pulmonary tuberculosis, with adhesions preventing complete collapse, two bronchiectases, three esophageal carcinomas and one exploratory thoracotomy for bronchial stenosis.

A further adjunct to anesthesia in which bronchial lumina are exposed or are to be exposed is abolition of the futile and dangerous paroxysm of coughing that occurs whenever the bronchial epithelium is touched. Patients with wide open bronchial fistulas have served as interesting subjects in the study of this reflex. For days after the bronchi are opened, even the gentlest touch of their epithelium with cotton will send the patients into a violent and entirely uncontrollable spasm of coughing. The cough alternates between several violent true coughs (forcible expulsion of air against the closed glottis) and a deep whoop or gasp as an interlude. The paroxysmal cough is annoying, and makes operation impossible while it continues; it is futile, and occurs not as a purposeful reflex because the patient has something to cough out, but because the bronchial mucosa is touched, and whether he has something to cough out or not. If the cough is annoying and futile, the sequence of cough and whoop is much more: it is dangerous. It is the cause of some of the fatal accidents that beset operation on the lung and against which the surgeon is powerless. The whoop probably opens the mouths

of the severed pulmonary veins, and the cough forces a great volume of air or infectious material into them under great pressure. Besides these immediately fatal sequels, the paroxysms of coughing aspirate and insufflate gangrenous material from one part of the lung to another and cause new areas of gangrene; a fatal pneumonia has followed injection of surgical solution of chlorinated soda (Dakin's solution) into an unsuspected bronchial fistula, the solution having been coughed violently into unaffected parts of the lung.

It has been noted curiously that the seat of this cough reflex seems to lie in the ciliated bronchial epithelium. The bronchial mucosa is extremely sensitive when it has been recently exposed; after a time the lung contracts and the open bronchi correspondingly widen, giving the exposed lung the appearance of a reticulated bladder (or as Sauerbruch terms it, a gridiron lung); the epithelium of the exposed bronchi and lung changes from ciliate to squamous. After this change the epithelium seems to lose its cough reflex; it may be touched with cotton or swabbed with various irritating solutions without causing a paroxysm. Neither does the reflex lie in the lung itself; irritating the raw section of the lung has no effect, provided care is taken to avoid open bronchial lumina. Further proof that the reflex is entirely one of the surface and of the mucosa itself lies in the fact that instillation of cocaine abolishes it.

We are indebted to Sargent and Forestier for this useful help to anesthesia. They anesthetize the bronchi with cocaine before injecting iodized oil. As the cough reflex is abolished by this method, it was a natural step to use it in operations in which open bronchi were to be encountered. If an open bronchial fistula exists, from 1 to 2 cc. of 4 per cent cocaine solution with 5 drops of epinephrine hydrochloride is instilled into it with an eye dropper or a syringe. The patient promptly reacts with a cough, sprays the cocaine about through his bronchial tree, coughs some of it out and then coughs no more. If the bronchi are not open, a hypodermic needle is introduced into the trachea between two of its rings, and 1 or 2 cc. of 4 per cent cocaine-epinephrine hydrochloride solution is injected into it. Procaine hydrochloride would probably be safe; I have not tried it.[1] One must be sure that the needle is in the trachea; the plunger should always be pulled back and air drawn from the tracheal lumen before cocaine is injected. The bronchial mucosa reacts almost immediately; the cocaine itself causes a cough, but a minute or two later the mucosa is insensitive and excites no further paroxysm when it is handled.

1. But I shall. Two recent respiratory disturbances after cocaine were alarming enough to dissuade me from the use of this drug if procaine can be used in its stead.

The persistent paroxysmal cough of mediastinal pleurisy and conditions at the root of the lung might cause suspicion that the cough reflex may originate elsewhere than in the bronchial mucosa. This is true; manipulation of certain places at the hilum or in the mediastinum will cause paroxysms even after the bronchial mucosa is anesthetized.

H. J. had an exploratory thoracotomy done under local anesthesia and preliminary pneumothorax for an intermittent bronchial stenosis of unknown, probably extrabronchial, origin. At operation many dense adhesions were discovered between the medial surface of the left upper lobe and the mediastinum. Severing or making traction on these caused a cough so violent that it was almost impossible to hold the distended lung aside, neither anesthetizing the bronchus with cocaine nor a light chloroform inhalation anesthesia sufficed to stop the cough.

The so-called pleural reflex remains for comment. This had better be called the pulmonary reflex. In none of the deaths reported after pleural puncture can one be sure that the lung was not entered. The greater vessels of the lung are extremely sensitive; clamping them or transfixing them with a ligature not infrequently causes profound shock. This has been noted in cases in which air embolism and other causes of sudden death can be excluded.

Mrs. F., aged 42, was operated on with a galvanocautery for bronchiectasis. The pleura had been caused to adhere. Two weeks later, the wound was opened under gas and local anesthesia. The packing was removed. The lung was adherent to the pleura. An attempt was made to find a bronchus with a needle in order to inject cocaine; however, as no air appeared in the syringe, cocaine was not injected. Then with a cautery a pyramidal piece of lung was excised which included a section of bronchus about the caliber of a slate pencil and 1.5 cm. long. Cocaine was injected into this bronchus centrally; a grooved director was inserted into it distally, and the distal tract slit with a galvanocautery, opening a bottle-shaped bronchiectasis half the size of a walnut. The central end was followed to within 1.5 to 2 cm. of the hilum. A spurting branch of the pulmonary artery was grasped with a Kocher hemostat. At this juncture the patient, who had hitherto breathed and had given the anesthetist no anxiety, suddenly stopped breathing. She was turned around. She was pale, and no heart sounds were to be heard. It was apparent that death was due to heart failure and not to failure of respiration. One cubic centimeter of pituitary extract was injected into the chamber of the heart, but the pulse never again appeared.

At necropsy the right side of the heart was found dilated to two or three times the size of the left.

Whether injection of procaine hydrochloride under the pleura of the hilum of the lung can diminish the intensity of this reflex or abolish it remains to be seen. For the present, I think it safer to anesthetize the patient with nitrous oxide before clamping or tying the vessels at the root of the lung. The anesthetic, it is true, will distend the collapsed lung; however, after the root of the lung has been secured by clamps or ties and the operation is almost ended, distention of the lung is no longer objectionable.

The visceral pleura and the surface of the lung are quite insensible; neither is the normal parietal pleura extremely sensitive. Patients have not complained of pain when retractors have been introduced into the chest or when the parietal pleura has been touched, so that extensive subpleural infiltration with procaine or extensive blocking of the intercostal nerves has not seemed necessary. Pleuritic adhesions, however, are extremely sensitive; the inflamed pleura probably reacts more keenly to stimuli than the normal one. Patients complain bitterly when adhesions are touched or pulled on; even large subpleural injections of procaine hydrochloride have not sufficed to make their division painless.

PROCEDURE IN OPEN THORACOTOMY

A week or ten days before operation artificial pneumothorax is induced; 750 cc. of air is usually given at the first sitting, two or three days later 1,000 cc., and again after two or three days another 1,000 cc. The amounts and intervals vary; the object is to produce a complete collapse of the affected side without compressing it strongly enough to push the mediastinum toward the sound side. Insufflation of air will therefore stop when the manometer reads zero. Bronchiectatic lobes collapse incompletely; after pneumothorax the sound lobes are completely collapsed; the bronchiectatic one projects into the pneumothorax, being kept distended by its fibrosis and rigidity. An hour before operation one-fourth grain of morphine and $\frac{1}{150}$ grain of atropine are given. This is sometimes followed in fifteen minutes by a mixture of 2 or 3 ounces (59 or 89 cc.) of ether, 2 drachms of paraldehyde and 2 ounces of olive oil instilled slowly into the rectum through a fine catheter. Rectal ether seems to work best in placid, phlegmatic patients; it seems to excite excitable ones; weak or frail ones seem to stand it badly or are slow to recover from its effects. An additional one-sixth grain (0.01 Gm.) of morphine may be given just before operation. It is not necessary to have the patient empty his lung by coughing; the preliminary pneumothorax has emptied it for him.

A 0.75 per cent solution of procaine hydrochloride containing 2 drops of 1:1,000 epinephrine hydrochloride to the ounce is injected subcutaneously along the line of incision in order to save waiting twenty minutes for a nerve block to take effect, but the intercostal nerves innervating the same line are injected with the same solution. If the lung is to be severed, 1 or 2 cc. of 4 per cent cocaine or procaine hydrochloride solution with 5 drops of epinephrine hydrochloride is injected into the trachea with the patient upright or semiupright. Much of this cocaine is expelled by coughing. In extrapulmonary operations the air passages are not anesthetized by cocaine. The chest is now opened and operation proceeds.

I do not know whether to recommend subpleural injection of procaine hydrochloride at the hilum. It was effective in a recent operation for esophageal carcinoma; in a recent lobectomy it was not, but here the patient was excited and talkative after rectal anesthesia.

I should like to make it clear that I am not warmly advocating local anesthesia in thoracotomy. I am not sure of its advantages; indeed, I am sure that a general narcosis, if it can be safely carried out, is much to be preferred, and is easier and less shocking to the patient than

these tours de force with local anesthetics. I am, however, equally sure that preliminary artificial pneumothorax with collapse of the affected lung is of great value, and that pressure anesthesia with its unavoidably sudden and violent inflation and collapse of the lung is harmful. So rather than dispense with the ease and accuracy and ability to see that go with operation on a patient who is breathing quietly and without strain, with a lung that lies collapsed and out of the way at the bottom of the chest, I have resorted to the methods of overcoming pain without disturbing the respiratory equilibrium of the open pneumothorax that I had at my disposal, namely, local anesthesia and rectal ether anesthesia. If, however, Branower's machine will let the collapsed lung stay collapsed and keep the unaffected one breathing quietly while the patient is under general anesthesia, then this method in combination with preliminary pneumothorax and blocking of certain of the intercostal nerves should be ideal.

Quiet respiration is a sine qua non for the maintenance of collapse, so that combination with any of the ordinary inhalation methods of anesthesia is not feasible.

SUMMARY

Preliminary artificial pneumothorax is a valuable aid in open thoracotomy for operations on the thoracic viscera.

It causes less shock and less circulatory disturbance than any of the pressure methods of anesthesia.

It may be used in conjunction with local anesthesia, and aided further by rectal ether anesthesia; possibly, by certain forms of inhalation anesthesia.

Irritation of the bronchial mucosa causes a paroxysmal cough reflex.

This reflex disappears after the open bronchial mucosa changes from ciliary to squamous epithelium.

Abolition of the paroxysmal cough reflex by anesthetizing the bronchial tree with cocaine is valuable in opening into the bronchial lumen.

490 Port Street.

ABSTRACT OF DISCUSSION

DR. FRANZ TOREK, New York: I was interested in hearing that Dr. Eloesser has used the intrapleural pneumolyses in five cases. I wrote an article on this topic about twelve or thirteen years ago. That was previous to the time that thoracoplasty had reached its present perfection of technic. I have never had occasion to repeat the operation, because tuberculous patients are not admitted to the hospital with which I am connected. This particular patient was there by accident; she was so sick she could not be sent away. But I would have repeated the method. I am glad to hear that somebody else has done it and has persisted in doing it; Dr. Eloesser repeated it five times. I had believed that the consensus of opinion was that my operation was worthless, because I

had never heard of anybody repeating it. I still believe there is a place for this method of producing pneumothorax in cases in which the presence of adhesions makes an ordinary injection of air into the chest cavity impossible.

Dr. Howard Lilienthal, New York: I was interested to hear of the application of the pneumothorax method, which I had known of before and read of in the literature. It has been recommended, in the discussion of operations on lung tumors, as a preliminary step.

I must take issue with Dr. Eloesser on the question of pleural or pulmonary reflex. His patient had been operated on; there was induration, bleeding and an open bronchus. That induces cerebral air embolism. This accident will be seen only in cases in which there has been previous operation or previous disease leading to infiltration of the parts, so that the branches of the pulmonary vein are held open. It takes surprisingly little air to get into one of these open veins and go directly to the brain, producing a series of convulsions and death. I think if Dr. Eloesser will read Schlaepfer's article on this subject, he will be convinced that pleural shock does not exist as such. People have tried to produce pleural shock by painting the pleura of animals with iodine. I do not think they have succeeded. I do know I have painted the pleura of half the chest with iodine in order to make adhesions, and I have done it three or four times without a sign of shock. In three days the iodine will make adhesions. This is done as a preliminary to lobectomy. I think it is important that this society should not tacitly give its consent to the idea that there is such a thing per se as pleural or pulmonary shock.

Dr. Carl Hedblom, Chicago: I should like to discuss some phases of the general problem of pneumothorax, but this is not the time to introduce that subject. I do want to say that I believe there is something that is not as yet understood concerning so-called pleural or pulmonary reflex or pleural eclampsia, or whatever it may be called. I believe that there are different types and that there are different causes for the same clinical manifestations, more or less. For instance, within the last month I had a patient on whom I was going to perform a second stage extrapleural thoracoplasty for bronchiectasis. I had just opened the incision that I had made at the first operation when the patient went into convulsions. The pupils dilated; she became intensely cyanosed, and apparently reached the last stage of dissolution, then gradually revived. I cannot see how these symptoms could possibly have been due to air embolism. The pleura was not touched. Possibly the nitrous oxide anesthesia was the etiologic factor. I have had other cases which in my opinion cannot be explained as due to air embolism. There is more to the problem of so-called pleural reflex, I believe, than air embolism. I was very much interested in Dr. Eloesser's presentation of the matter of pneumothorax preliminary to thoracoplasty. As Dr. Lilienthal has just said, the method was described years ago. Under certain conditions it seems worth further trial, but I would want to be conservative in the matter of thoracotomy for pneumolysis in pulmonary tuberculosis. I have had patients who have developed tuberculous empyema with complete collapse of the lung following such operations performed elsewhere, and some of those have been among the most difficult I have had to treat.

Dr. Willy Meyer, New York: The paper of Dr. Eloesser is interesting, even if he has not been the first to do what he did. It shows how a surgeon can sometimes help himself under difficult conditions. I should like to mention the original statement of Sauerbruch, that it would be wrong for the surgeon to

use local anesthesia within the healthy pleura. He made this statement after he had performed a great many operations. He says that it is absolutely necessary to use general anesthesia. It is known that the nerves play an important rôle in thoracic operations in which the pleura is wide open. With so many thoracic operations being performed at the present time, it will be of interest to follow this question further as to the use of regional and local anesthesia.

Dr. Leo Eloesser, San Francisco: Dr. Torek has driven me into a corner. I hesitated to bring my misdemeanors before this august assemblage. I approached the intrapleural pneumolyses with anxiety; I performed four in 1922, then stopped until this year, when I performed one. But God was good to me. Three of the patients are cured and one much improved. Of course it is too early to report on the operation performed this year. I am sorry not to have been more explicit in my designation of the pulmonary reflex. It is not a pleural reflex; it is a pulmonary reflex. I am grateful to Dr. Lilienthal for calling my attention to deficiencies in reading; I looked about for descriptions of pneumothorax as a method preparatory to anesthesia but was unable to find any. I shall look up Ballinger's method. I have not seen it used at any of the clinics I have visited. Of course, I do know Schlaepfer's work and was extremely interested in it. In fact, I had an ophthalmologist, Dr. Barkan, look at the eyegrounds of various rabbits on which these procedures were attempted. He could see bubbles of air in the retinal vessels, just as Becker and Stargardt did, when there was a pulmonary air embolism. However, the patient I spoke of did not die of air embolism. She died after clamping a pulmonary artery. I was particular to make as careful a necropsy as I could. There was no air embolism, but the right side of the heart was much dilated. Dr. Meyer's case is of great interest. Air embolism was not present in his case, because no vessels were opened. In mine there was no embolism. I hope at some future time to be able to tell you more about this. I think nerves may be found following the large pulmonary arteries leading to the right side of the heart which if crushed or clamped suddenly will produce a fatal reflex.

PROCEEDINGS

Wednesday, September 29—Evening

The council met at the Mount Royal Club at 9:30 p. m.

Thursday, September 30—Morning

The meeting was called to order at 9 a. m. by the president, Dr. Edward W. Archibald, at the Ritz Carlton Hotel.

Dr. Stuart W. Harrington, Rochester, Minn., read a paper on "The Surgical Treatment of Intrathoracic Tumors and Tumors of the Wall of the Chest." Discussion was opened by Dr. Howard Lilienthal, New York, who was followed by Drs. Willy Meyer, New York; Leon T. LeWald, New York; Carl A. Hedblom, Chicago; Jacob J. Singer, St. Louis; Edward W. Archibald, Montreal, and Stuart W. Harrington, Rochester, Minn.

Drs. Adrian V. S. Lambert, New York, and Frank B. Berry, New York, by invitation, presented a paper on "The Mediastinum: Anatomic and Clinical Study." Discussion was opened by Dr. Hugh Auchincloss, New York, who was followed by Drs. Howard Lilienthal, New York; Nathan W. Green, New York; William Lerche, St. Paul, and Adrian V. S. Lambert, New York.

Dr. David T. Smith, Ray Brook, N. Y., by invitation, read a paper on "Experimental Aspiratory Abscess." Discussion was opened by Dr. Willy Meyer, New York, who was followed by Drs. Adrian V. S. Lambert, New York; Howard Lilienthal, New York; Nathan W. Green, New York; Frederick T. Lord, Boston; Leo Eloesser, San Francisco, and David T. Smith, Ray Brook, N. Y.

Dr. Frederick T. Lord, Boston, read a paper on "The Diagnosis and Treatment of Eventration of the Diaphragm, with a Report of Four Cases."

Dr. Edward N. Packard, Saranac Lake, N. Y., by invitation, read a paper on "Hernias of the Mediastinum During the Course of Artificial Pneumothorax."

These two papers were discussed by Drs. Jacob J. Singer, St. Louis; Carl A. Hedblom, Chicago; John L. Yates, Milwaukee; William Lerche, St. Paul; Leo Eloesser, San Francisco; Willy Meyer, New York; Howard Lilienthal, New York; Leon T. LeWald, New York; Edward S. Welles, Saranac Lake, N. Y., and Frederick T. Lord, Boston.

Thursday, September 30—Afternoon

The meeting was continued at the Ritz Carlton Hotel.

The following papers were read as a symposium on "Lung Mapping by Insufflation and Bronchoscopic Injection Methods, and the Roentgen-Ray Interpretation thereof."

Dr. Jacob J. Singer, St. Louis: "Bronchography (Injection of Iodized Oil, 40 per cent)."

Dr. Gabriel Tucker, Philadelphia: "The Technic of Bronchoscopic Introduction of Bismuth Subcarbonate and Iodized Oil, 40 per cent, for Pneumonography."

Dr. David H. Ballon, Montreal, by invitation: "Pneumonography with Iodized Oil, 40 per cent, by the Bronchoscopic Method."

Dr. David A. Stewart, Ninette, Manitoba: "Etiology and Differential Diagnosis in Septic Conditions of the Chest."

Dr. Edward W. Archibald, Montreal, presented cases illustrating the value of injections of iodized oil, 40 per cent, in diagnosis and in controlling the results of treatment.

These papers were discussed by Drs. Frederick T. Lord, Boston; A. L. Lockwood, Toronto; Franz Torek, New York; Howard Lilienthal, New York; James H. Kernan, New York; Willy Meyer, New York; Carl A. Hedblom, Chicago; David T. Smith, Ray Brook, N. Y.; Jacob J. Singer, St. Louis; Gabriel Tucker, Philadelphia; David H. Ballon, Montreal; Edward W. Archibald, Montreal, and David A. Stewart, Ninette, Manitoba.

Thursday, September 30—Evening

The annual banquet was held in the Ritz Carlton Hotel. Dr. Edward W. Archibald, Montreal, delivered the President's Address.

Friday, October 1—Morning

The meeting was continued at the Ritz Carlton Hotel.

Dr. William F. Hamilton, Montreal, by invitation, read a paper on "Nontuberculous Pulmonary Disease." Discussion was opened by Dr. Willis S. Lemon, Rochester, Minn., who was followed by Drs. Frederick T. Lord, Boston; Howard Lilienthal, New York; Nathan W. Green, New York; Jacob J. Singer, St. Louis; David T. Smith, Ray Brook, N. Y.; Edward W. Archibald, Montreal, and William F. Hamilton, Montreal.

Dr. Carl A. Hedblom, Chicago, read a paper on "Late Results of Thoracoplasty for Bronchiectasis." Discussion was opened by Dr. Howard Lilienthal, New York, who was followed by Drs. Willy Meyer, New York, and Stuart W. Harrington, Rochester, Minn.

Dr. Willis S. Lemon, Rochester, Minn., read a paper on "The Physiologic Effect of Phrenic Neurectomy."

Dr. Howard Lilienthal, New York, read a paper on "The Logical Sequence in Two-Stage Thoracoplasty."

These two papers were discussed by Drs. Edward S. Welles, Saranac Lake, N. Y.; John L. Yates, Milwaukee; Leo Eloesser, San Francisco; Edward W. Archibald, Montreal; Willis S. Lemon, Rochester, Minn., and Howard Lilienthal, New York.

Friday, October 1—Afternoon

The meeting was continued at the Ritz Carlton Hotel.

The association met in executive session to elect new members, elect officers, and consider a revision of the constitution (a draft of the new constitution follows these proceedings), and to transact such other business as should formally come before it.

Dr. Howard L. Beye, Iowa City, read a paper on "Transphrenic Infection: Report of Ten Cases." This paper was discussed by Dr. Edward W. Archibald, Montreal.

Dr. Leo Eloesser, San Francisco, read a paper on "Preliminary Artificial Pneumothorax in Operations on the Open Chest, with Clinical Observations on the Sensibility and Reflexes of Various Parts of the Lung, and Experiences with Various Methods of Anesthesia." Discussion was opened by Dr. Franz Torek, New York, who was followed by Drs. Howard Lilienthal, New York; Willy Meyer, New York; Carl A. Hedblom, Chicago, and Leo Eloesser, San Francisco.

Dr. John L. Yates, Milwaukee, read a paper on "Rationale of Operations Helpful in Promoting Recoveries from Pulmonary Tuberculosis." Discussion was opened by Dr. Edward W. Archibald, Montreal, who was followed by Drs. Adrian V. S. Lambert, New York; Howard Lilienthal, New York, and A. T. Lockwood, Toronto.

Dr. Edward S. Welles, Saranac Lake, N. Y., read a paper on "An Accessory Thoracoplastic Operation to Aid in the Collapse of Large Tuberculous Cavities."

Dr. Willy Meyer, New York, read a paper on "Anesthesia in Tuberculous Patients Requiring Extrapleural Thoracoplasty." Discussion was opened by Dr. A. T. Lockwood, Toronto, who was followed by Dr. Willy Meyer, New York.

Dr. William Lerche, St. Paul, read a paper on "Infected Mediastinal Lymph Nodes as a Source of Mediastinitis." Discussion was opened by Dr. Edward W. Archibald, Montreal, who was followed by Dr. William Lerche, St. Paul.

Dr. Leon T. LeWald, New York, read a paper on "Congenital Absence of the Left Half of the Diaphragm."

Saturday, October 2—Morning

The meeting was continued at the Royal Victoria Hospital.

Operative clinics and dry clinics were held by Dr. Edward W. Archibald and other Montreal members of the association.

TENTATIVE DRAFT OF CONSTITUTION FOR THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

Article I.—Name

Section. 1.—This Association shall be known as the American Association for Thoracic Surgery.

Article II.—Object

Sec. 1.—The object of the Association shall be to encourage and stimulate investigation and study that will increase the knowledge of intrathoracic physiology, pathology and therapy, to correlate such knowledge and disseminate it.

Sec. 2.—To attain this object, the Association shall hold at least one scientific meeting every year in which free discussion shall be featured; shall publish annually the transactions of that meeting; shall cooperate with other organizations working toward the same end, and shall undertake such other activities as the Council or the Association as a whole may decide.

Article III.—Membership in Congress

Sec. 1.—As a component member of the Congress of American Physicians and Surgeons, this Association subscribes to the Constitution and By-Laws of the Congress.

Article IV.—Membership

Sec. 1.—There shall be four classes of members: Active, Associate, Senior and Honorary. Admission to membership in the Association shall be by election. Membership shall be limited, the limits on the respective classes to be determined by the By-Laws.

Sec. 2.—Membership may be voluntarily terminated at any time by members in good standing. The Council, acting as a Board of Censors, may recommend the expulsion of a member on the grounds of moral or professional delinquency, and submit his name, together with the grounds of complaint, to the Association as a whole at any of the regularly convened meetings, after giving the member so accused ample opportunity to appear in his own behalf.

Article V.—Officers and Government

Sec. 1.—The officers of the Association shall be a President, a Vice President, a Secretary, a Treasurer, and five Councilors. These nine officers and councilors shall be the governing body of the Association, and shall have full power to act in all matters, except as follows:

1. They may not alter the initiation fees or annual dues, nor levy any assessments against the membership.

2. They may in no wise change the Constitution or By-Laws.

3. They may neither elect new members nor alter the status of existing members.

4. They may not deplete the principal of the Endowment Fund.

Sec. 2.—Officers and Councilors shall be elected at the annual meeting of the Association, and shall take office on the first day of January, next succeeding. The President and the Vice President shall be elected for a one year term of

office and neither may be reelected to succeed himself in the same office. The Secretary and the Treasurer shall be elected for a one year term of office and either or both may be reelected indefinitely. The outgoing president shall automatically become a councilor for a one year term of office. The other four councilors shall be elected, one each year, for a four year term of office, but no councilor may be reelected to succeed himself.

SEC. 3.—Vacancies occurring among the officers and councilors during the year shall be temporarily filled by action of the Council, subject to approval of the Association at the next regularly convened meeting.

ARTICLE VI.—COMMITTEES

SEC. 1.—At the opening session of the annual meeting there shall be elected after nomination from the floor of the Association a Nominating Committee of three. This Committee shall prepare a slate of nominees for officers and councilors and shall present their report at the executive session of the Association.

SEC. 2.—The Council is empowered to appoint a Membership Committee, an Auditing Committee, a Committee on Program and Transactions, a Necrology Committee and such other committees as may in its opinion be necessary. All such committees shall render their report at the executive session of the Association.

ARTICLE VII.—FINANCES

SEC. 1.—The fiscal year of the Association shall coincide with the calendar year. The books of the Association shall be kept and audited on this basis.

SEC. II.—Members shall contribute to the financial maintenance of the Association through the medium of initiation fees, annual dues and special assessments. The amount of the annual dues and the initiation fees shall be determined by the By-Laws.

Special assessments may be charged against individual members, as determined by the By-Laws, when material submitted for publication in the annual transactions of the Association exceeds such limits as may be set in the By-Laws. If, at the end of any fiscal year there be a deficit in the current funds of the Association, the Council may send out notices to that effect and invite Active Members to contribute the necessary amount so that no deficit be carried over from one fiscal year to another. The Association may, in any regularly convened meeting, vote a special assessment for any purpose whatever, and such special assessment shall become an obligatory charge against the classes of members affected thereby.

SEC. III.—To meet the current expenses of the Association, there shall be available all revenue derived from annual dues, special assessments, and income from Endowment Fund, subject to the provisions of Section IV following. Funds derived from the payment of initiation fees shall not be available for current expenses.

SEC. IV.—All funds derived from the payment of initiation fees shall be placed in a special fund, to be invested and reinvested in legal securities, and to be held intact as an Endowment Fund. The Council is responsible for the proper management of the Endowment Fund. The income from this fund may be utilized for such purposes as may be determined in the By-Laws. If at the end of any fiscal year there be a surplus in the current funds of the Association, the Council may divert such surplus into the Endowment Fund, but in no case may the

Council divert any of the principal of the Endowment Fund into the current account of the Association.

In the event of the dissolution of the Association, the Endowment Fund shall be distributed among national institutions of the United States and Canada in a proportion equal to the then existing ratio between the numbers of citizens of the two nations who are members of the Association.

Article VIII.—Meetings

Sec. I.—The time, place, duration and procedure of the annual meeting of the Association shall be determined by the Council, subject only to the requirements of the Congress of American Physicians and Surgeons, and the provisions of the By-Laws.

Sec. II.—A special meeting of the Association may be called on one month's notice on the written request of fifteen members. The specific purposes of the meeting must be stated in the request and in the official call for the meeting.

Sec. III.—The annual meeting of the Council shall be held during January.

Article IX.—Amendments

Sec. I.—This Constitution shall in no wise be changed except by a three-fourths vote of the members present at an annual meeting, and further provided that the proposed alteration or amendment shall have been moved and seconded at a previous annual meeting, and that printed copies of the suggested alteration or amendment shall have been circulated among the members, and that the members shall have been specifically advised that such alteration or amendment will be voted upon.

LIST OF MEMBERS OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

Honorary Members

Dr. Edward R. Baldwin.....6 Church St., Saranac Lake, N. Y.
Dr. Alexis Carrel.....Rockefeller Institute, New York.
Dr. Norman B. Carson, c/o Mrs. Newton B. Wilson, 4 Brentmoor Park, St. Louis.
Dr. Georges Dehelly.....25 Rue Henry Genestal, Le Havre, France.
Dr. Alfred Meyer.....Apt. 16 E., 1225 Park Ave., New York.
Dr. S. Adolphus Knopf.....16 West Ninety-Fifth St., New York

Active Members

Dr. John Alexander.....The Corey Hill Hospital, Brookline, Mass.
Dr. Carroll W. Allen.....509 Macheca Building, New Orleans.
Dr. Duff S. Allen.....Washington University Medical School, St. Louis
Dr. William DeWitt Andrus.....Cincinnati General Hospital, Cincinnati.
Dr. Edward W. Archibald.....52 Westmount Boulevard, Montreal.
Dr. Hugh Auchincloss.....Presbyterian Hospital, New York.
Dr. A. T. Bazin.....Montreal General Hospital, Montreal.
Dr. Emil G. Beck.....2551 North Clark Street, Chicago.
Dr. Ralph B. Bettman.....104 South Michigan Avenue, Chicago.
Dr. Frank K. Boland.....436 Peachtree Street, Atlanta, Ga.
Dr. William Branower .....1815 Seventh Avenue, New York.
Dr. Lawrason Brown.....104 Main Street, Saranac Lake, N. Y.
Dr. Harold Brunn.....350 Post Street, San Francisco.
Dr. Ethan F. Butler.....Robert Packer Hospital, Sayre, Pa.
Dr. J. Roddick Byers.....74 Westmount Boulevard, Montreal
Dr. A. H. W. Caulfield.....13 Spadina Road, Toronto
Dr. Rufus Cole.....960 Park Avenue, New York.
Dr. Samuel J. Crowe.....Johns Hopkins Hospital, Baltimore.
Dr. Armistead Crump.....20 West Fiftieth treet, New York.
Dr. Elliott Carr Cutler.....Lakeside Hospital, Cleveland.
Dr. T. C. Davison.....Suite 35, Doctors' Building, Atlanta, Ga.
Dr. Victor P. Diederich.....Hot Springs, Ark.
Captain Chauncey E. Dovell, M.C., U. S. Army.....Fort Monroe, Va.
Dr. Kennon Dunham.....1020 Union Central Building, Cincinnati.
Dr. Edmond M. Eberts.....219 Peel Street, Montreal.
Dr. Carl Eggers.....850 Park Avenue, New York.
Dr. Max Einhorn.....20 East Sixty-Third Street, New York.
Dr. Leo Eloesser.....738 Butler Building, San Francisco.
Dr. Charles A. Elsberg.....64 East Fifty-Eighth Street, New York.
Dr. R. G. Ferguson..Saskatchewan Sanatorium, Fort Qu'Appelle, Saskatchewan.
Dr. Hermann Fischer.....73 East Eightieth Street, New York.
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